JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

DECEMBER, 1862.

CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL McELROY, C. E.

PUMPING ENGINES No. 3. (Continued.)

(Continued from p. 300.)

Force Lift.—Under this head we may consider the action which pertains to pumps, independently of the suction lift, with some preliminary allusion to different classes of pumps.

Pumps may be divided in two general classes; those which are *single-acting*, in delivering a single charge by a revolution or double-stroke; and those which are *double-acting*, delivering a double charge, for each revolution or double-stroke.

Single-acting pumps may be divided in two general classes; *bucket* pumps, and *piston* or *plunger* pumps; of these the first operate in one direction only, and the second operate in one direction on the suction lift, and in the other, on the force lift.

Bucket pumps are to be found in the lower lifts of the Cornish mines, supplying the first cistern for the plunger lifts. They have the advantage of being more readily lowered to suit the changes in level of the well, and the buckets can be drawn out for examination and repacking through the delivery pipes, in case the pumps should be flooded. The leather packing used, seems to be defective in requiring frequent renewals, varying from a few days to two or three months. The several lifting pumps of the large Haarlem Meer Engines, are of this class, the buckets being attached by chains to the rods, with but-

terfly valves, which lift on the hinges about 1·5 inch in descending. Each pump of the Brooklyn engine is also single-acting, in which the valve is a "double-beat" playing on the rod; an application which we believe to be original, and which works admirably. The pumps of the New York Dry Dock engine, and others of the kind, are single-acting, and there are single-acting buckets in compound pumps as in the case of the Hartford engine. The common-hand pump belongs to this class. In some of these cases foot valves are used, and in others their use is superseded.

Single-acting piston pumps are used in some of the mining engines at Bavaria, one of which has a lift of 1168 feet: at the Huelgoat mine in France, with a lift of 754 feet; at the Boulton and Watt engine, East London Water Works, the Wolverhampton engine, and others in various places. In these cases the pump chamber is placed one side of the pumping main, while the foot valve on the suction tube, with the delivery valve on the forcing tube, are above its upper centre. At Huelgoat these valves are on the common centre line of the main, so that except the current into the pump chamber on the descending stroke, which makes the suction lift, and the return current on the force lift, the line of delivery is not changed. At East London and at Wolverhampton the pump chamber stands between the suction and forcing tubes, the lines of delivery being abruptly changed in direction, at the pump head.

Single-acting plunger pumps are used in the upper lifts of the Cornish mines, in the single-acting water works engines, and in some which are double-acting. The suction lift is made on the up-stroke, and the force lift on the return stroke. In the mining engines the valve-chest is in the centre line of the main, as in the Huelgoat main, but in the water works engines, the foot valve-chest is generally placed below the plunger, the current turning with a right angle into the delivery valve-chest above and on one side of it, passing thence by a goose-neck turn into the air-chamber or stand-pipe base, making three right-angled changes of direction, in addition to the pump current. In the mining pumps the lifts are usually from 180 to 240 feet each, the whole discharge being made into a cistern placed at each station, from which it is redrawn and reforced, lift by lift to the summit, which in some cases is 1300 feet above the well.

Double-acting pumps are used with both pistons and plungers—vertically, inclined and horizontally—plungers being exceptional to the general practice.

Horizontal or inclined piston pumps, with suction and delivery side-pipes, fitted with metallic or rubber clack valves, are the most common. There are several specimens at Philadelphia, Pittsburg, and other Northern, Southern and Western cities, worked by cranks from a fly-wheel shaft, or by a half-beam. In the Spring Garden engine house there are two engines with a double-acting vertical pump under each cylinder, worked by the piston rod prolonged, in a fly-wheel beam engine. At New Orleans two beam engines work vertical pumps, in which the water valves are controlled by eccentrics.

At Charleston and at Cambridge horizontal plunger-pumps are in use, with a diaphragm in the pump-chamber, which provides for double-delivery, the plunger being worked by a rod passing through a stuffing-box. The valves are small india-rubber clacks on a grating, the delivery-tube being attached to one side of the pump-chest. A modification of this plan retains the advantage of plunger-packing, by dispensing with the diaphragm and separating the pump-chambers, so as to use two stuffing-boxes on the same plunger.

The pump usually known as the "Ditton" pump, is double-acting so far as it combines both the plunger and the bucket in the same barrel, but it is single-acting so far as it delivers at one revolution only the charge due to its bucket area and stroke. Here the plunger is made half the area of the bucket, which is attached below it; the foot valve retains above it, on the down stroke, the charge drawn up by the bucket on the up stroke, of which one-half is forced into the main by the descending plunger, and the other half by the bucket on the return stroke; in this case the forcing load on the bucket is in part counterbalanced by the load on the plunger area, while it carries the whole suction load.

Before comparing these various systems, we may refer to the relative merits of the details of plungers, pistons and buckets, valves having been already discussed.

The general adoption of the plunger with its stuffing-box, as invented by Sir Samuel Morland, in 1675, or rather improved on much more ancient use, has led to the assumption that its advantages are peculiar to itself. While it is claimed to have less friction, its facility of access, inspection, and repair, is important. As compared with the piston or bucket pump, in point of construction, there is a choice between boring a barrel or turning a plunger, the amount of metal used being in excess for the latter, but the plunger pump is the most simple; as to the relative friction, this is determined in either case by the amount of rubbing surface and the pressure, and therefore, except the stuffing-box of the piston rod, may be no more in one case than in the other; if the exposed stuffing-box on one hand admits open inspection and nice adjustment, the exposed piston (single-acting) also admits this, and may easily carry a movable stuffing-box. The enclosed piston or bucket, which was discarded for its rudeness in the mines, as to its valves and packing, may be brought up to a high standard of efficiency by careful workmanship, so as to need no re-packing for months and years, as at Spring Garden and Brooklyn. There is the disadvantage that cases of leakage are not immediately apparent, and cannot be remedied with an engine in motion. So that, in fact, as is generally the case in machines, correct workmanship and careful supervision really determine the matter, and may attain satisfactory results in either way.

Of these pumps the several classes of movements may be thus specified:—

The Pittsburg arrangement on each stroke makes an abrupt turn from the suction tube or side-pipe, through the valve-chest into the

pump-cylinder, reversing the motion on the return stroke. The passages are contracted and the valve openings small, while the motions are arbitrary and irregular, as taken from a crank. Hence there is much friction and the concussions are formidable.

The Ditton pump also takes its motion from the connecting rod of a crank engine, the result of which will be noticed under the head of *engines;* and while the lines of delivery are at right angles to the pump, the supply at each stroke is crowded past the plunger in such a manner as to involve considerable friction. If the plunger be enlarged so as to counterbalance the load on the up-stroke, the freedom of delivery is the more restricted. The friction due to both the plunger and bucket packing is encountered.

In the East London piston-pump, as at Wolverhampton, the current from the suction-tube is reversed by the piston, re-reversed on the return up-stroke, and passes through the abrupt turns of the delivery valve-chest.

In the single-acting water-works engine the lines of motion are thrice changed in entering the force-main, and the valve openings are somewhat restricted in practice, but admit of increase.

In the Huelgoat pump, as in the plunger mining-pumps, the current has the reverse due to the pump only, the suction and forcing tubes being in the same line, and large valve-openings admissible.

In the Cambridge pump, which is worked by a direct horizontal motion, there is nothing to prevent a direct line of delivery, as in the Huelgoat or mining-pump, or the use of equally valuable valves, except that the rapid motions due to a short stroke interfere with their use. As built the delivery is not direct.

In the Hartford pump two lifting-buckets are worked by spiral cams on the pump-shafts, in each of four vertical barrels, in such a manner that the suction or forcing charge of one bucket is passed through the other, which is not in operation in descending; that the working speed is slower than the return stroke; and that in transferring the load from one bucket to the other they both travel together for about one-twelfth of the stroke. This is an ingenious modification of an old arrangement, if we assume that the result, in equable delivery, could not have been more simply attained with much less friction. A modification of this idea, and of an ancient device, was adopted for the new Detroit engine in using two telescope barrels fitted with bucket-valves, which worked by spiral cams alternately towards and from each other. The engine itself did not pass acceptance, but the pump was much simplified in the use of a single delivery, without change of line, one of the errors at Hartford being the multiplication of small pumps and gearing, and the changes of line in supply and delivery.

In the Brooklyn engine the pump dimensions are large. The forcing charge of the lower bucket, under the cylinder, is carried by two right-angled turns through the upper pump, and thence by a third turn into the main, an action assumed by the upper bucket on its lift; freedom of delivery being favored by annular pump barrels outside of the working barrels, fitted with double-beat covers. In

this case the lines of motion are not reversed, and there are no contractions in the flow.

In the pumping arrangements of which these are representatives, we find not only single-acting pumps worked by single-acting cylinders, which take steam one way and make the return stroke by counterweights, but we find double-acting cylinders working two or more single-acting pumps in combination with the same main, as we also find them working double-acting pumps.

We also observe, in respect to delivery, that in single-acting pumps but one-half the quantity of water is delivered per double stroke, due to double-acting pumps, and that but one of the latter is usually worked by a cylinder, in practice, the double-acting cylinder and pump being equivalent in power to the same cylinder with two or more single-acting pumps.

Resuming, then, our leading subject of force-lifts, from this notice of pumps, intimately connected with it, we find that the relations of the suction-main on one side, the intermediate pump, and the forcing main, are controlled by mutual laws of action and arrangement, which affect maximum results.

It may be taken for granted that in dealing with a heavy, incompressible, mobile liquid like water, losses from friction, counteraction, and otherwise, are unavoidable, and that the problem of effect depends on their reduction to a minimum. The expensive construction, the concussions, accidents and repairs of pumping machinery of all kinds sufficiently illustrate the importance of this problem, and explains, to a certain extent, the endless varieties of machines which have been devised, and the differences of opinion as to practical remedies and results.

The proportions of a pump are adapted to the required delivery in a given time, and the assumed speed; those of the engine are adapted to the required load and speed, which measure the mechanical work. As the mains are generally long, and rapidly increase in cost with increased diameter, their size has considerable influence on the relative pump area, while the length of stroke is determined by convenience of engine construction and a certain assumed speed.

In water works, the item of present and a certain prospective demand, as a representative of annual income, regulates, or should regulate, the question of outlay in construction. As to the pumping main, this item of allotted capital and delivery should determine the calibre. The pump should be proportioned to the main, as to area; the speed to the rule of best practice in strokes per minute, fixing length of stroke, and the engine dimensions determined from the pump load and speed. But as a rule, we find proportion much neglected between pumps and mains, and arbitrary proportions adopted for the engines.

Imperfect pump-action is caused by frictional losses, counteractions, resistances and loss of charge, aggravated by conditions of speed, travel, concussions and irregular engine motions.

It may be taken as a rule that the pump diameter should never ex-

ceed that of the main; that the most perfect valves and most free opening are advisable; that all reactions in line of current motion are objectionable; that all changes in direction of supply and delivery are to be made as simple as possible; that the pistons, plungers or buckets are to be carefully made and packed to prevent leakage on one hand, and excessive friction on the other; that arbitrary movements during the stroke are to be avoided; that the greatest length of stroke is desirable; and that the impulses to the delivery-column should be regularly maintained without material pauses in action.

From the established law in flow of tubes that all contractions are sources of loss, the propriety of adapting pump diameter to that of the connecting tubes is apparent, not only from the frictional loss, but from the change of speed in the water-flow. Any difference between the rate of flow in the pump and main has an importance beyond that simply of the *vena contracta* in influx and efflux at the pump-chamber, or of valve friction. Enlargements are less objectionable than contractions, in the pump or main, but also produce reactions.

Changes of direction in line of flow cannot be usually avoided, and produce certain comparative frictional losses, but they are far less objectionable than reactions, or reverses in motion, which more directly affect and embarrass the *vis viva* of the water column.

Some of the operations of the water column will be more clear by examination of certain laws of motion.

The several classes of reciprocating pumps we have presented, represent two distinct doctrines of motion; one, which claims that maximum effect is to be produced by the most uniform flow of the column, and the other, that maximum effect, *ceteris paribus*, depends on a uniformly variable flow.

Uniform Motion.—The first school assimilates the force-main of a pump to the discharge-main of a reservoir, and objects to all abrupt or alternate changes of head, as far as attainable, regarding continuous flow as equally necessary in either. In accordance with this aim, we find the several combinations of pumps to a single main in frequent use, the entire class of short-stroke pumps, and the use of cam motion.

In the case of pumping arrangements which have been urged with great pertinacity, have been constructed and made the subject of very costly experiments to obtain a continuous current, it is represented that in this way economical results may be attained far surpassing those of any other class; that the valves may be made to open and close without noise or concussion; that the use of stand-pipes, air-chambers, or fly-wheels, may be dispensed with; and that all frictional losses are brought to a minimum. The following language has been used on this point:—

"A column of water that is passing through an ascending main from a pump that in fact produces a continuous flow, really becomes a fly-wheel to whatever machine may be used to furnish the power for driving the pump. If this machine be a reciprocating engine, this same fly-wheel, which the column of water may be called, becomes a regulator of the engine, and furnishes the means of carrying the principle of expansion

to the greatest limit, and of using power with useful effect to an extent that cannot be exceeded in its application to any other work."—*Detroit Water Works Report*, 1856.

It was also represented that the pumps would deliver more than their theoretical contents per stroke.

The arrangement to which this report specially refers, and which has been described under "single-acting bucket-pumps," was guaranteed to perform a duty of 1,000,000 foot-pounds per pound of coal, and was put under contract July 19, 1856, to be completed July 1, 1857; but as its construction was delayed until the spring of 1861, and the engine was then abandoned by its builders, these mechanical results have not been demonstrated.

The Hartford engine furnished the experimental basis of the theory under which this contract was made, under certificates of several engineers of "reputed skill in their profession." In November, 1855, an experiment at Hartford gave 423,439 ft.-lbs. pump-duty, and on the Belleville Cornish engine 846,277 ft.-lbs. Another experiment at Hartford, December 14, 1855, gave 584,704 ft.-lbs., and, deducting coal lost in getting up steam, 974,195 ft.-lbs. A third experiment gave 487,783 ft.-lbs., May 1st, 1856, and at Belleville, 513,295 ft.-lbs., which was reduced for "effectual duty" to 461,966 ft.-lbs. It was also calculated that the superior evaporation of the Belleville boilers entitled the Hartford pumps to an actual relative duty of 720,125 ft.-lbs. It was also certified by the experts of the last trial, that no air-chamber or stand-pipe was used, and that the pump indicator "did not perceptibly move during the trial, but gradually registered a greater pressure as the head of water was increased in the reservoir." As the contractors represented in the meantime, the opportunities of improvement over the objectionable gearing and arrangement of this engine, and a willingness to guarantee 1,500,000 such ft.-lbs. as those of the Jersey City engine, their contract-guarantee of 1,000,000 ft.-lbs. was not considered unreasonable.

In further experiments at Hartford the pump duty was made 550,681 ft.-lbs., December 5th, 1856, and 626,617 ft.-lbs. December 5th and 6th, on another trial, the Belleville pump duty being reported 718,013, 685,634 and 739,138 ft.-lbs. on three trials of December 19th and 20th, 1856. The duty at Hartford was also reported, July 16th, 1857, at 655,054, and 689,745 ft.-lbs. on two trials.

Reports like these are interesting, even when they embody the proof of their want, in some respects, of method and reliability, and illustrate some of our former remarks. The city of Detroit has spent $25,790 on one experiment, and for the engine-house specially adapted to it $56,876, and now votes $25,000 for another engine.

As the most prominent type of this particular school, the Hartford pump merits a closer description than has been already given.

Two vertical pump barrels are placed on each side of an intermediate horizontal force main, 16 inches in diameter, with which their deliveries are connected by a double goose-neck turning downward, the centre of the tube being about 5 inches above that of the pumps. Each

barrel is made with two diameters, the upper chamber, 19 $\frac{5}{16}$ inches, the lower, 18$\frac{3}{4}$ inches, taking two buckets fitted with butterfly valves, which are seated at an angle of 45 degrees. The lower bucket is operated by a rod 3$\frac{1}{8}$ inches diameter, which passes through the sleeve rod of the upper bucket, 4$\frac{5}{8}$ inches diameter (external), and is attached to a separate bell-crank. The pump motion is caused by bell-cranks operated by spiral cams from two geared shafts, reducing the engine speed, in the proportion of 80 to 27. The effective stroke during a revolution is 32$\frac{1}{4}$ inches, or 16$\frac{1}{8}$ inches for each bucket, the actual travel being 35$\frac{1}{4}$ inches, and the speed of each pump in delivery was 8 158 strokes double or 21·92 feet per minute, or 87·69 feet in all four, that of the force-main being 112·19 ft. The engine is condensing, with a fly-wheel, and with a cylinder of 5 feet stroke and 32$\frac{3}{8}$ inches bore, making 24·25 revolutions per minute, under an average piston pressure of 8 373 pounds. The equivalent pump lift was taken at 138·34 feet, length of main 6879 feet.

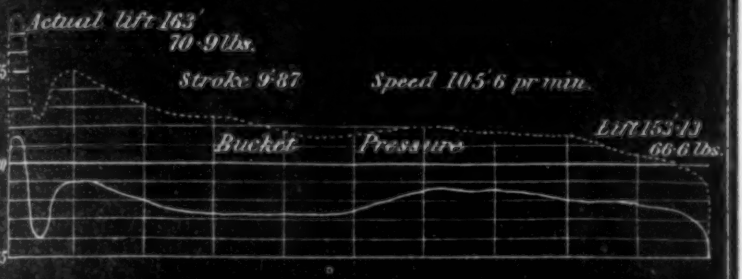
Measurements made at the reservoir with great care, for the experiment of December, 1856, showed a loss of action (or a difference between theoretical and actual delivery) of 6·56 per cent. in the pumps. This settled the argument of surplus delivery. It was also shown during that and other trials, that the small air-chamber which is placed on the main near the outboard pumps, had a very important effect on the smoothness of the pumping action and could not be dispensed with, nor could the speed of the pumps be increased, without producing concussions in the barrels.

With an arrangement of this kind, subdivided in eight working parts, which move together about one-twelfth of the time, each with slow speed, built with the most solid foundations and most careful workmanship, it might be assumed that this doctrine has a most favorable development, and uniform flow would be readily attained, with all its benefits. But the pressure pump card given in Plate II, from one of these pumps, and repeatedly duplicated by the indicator, goes to show conclusively that the doctrine is at fault. It must be remembered that in this case there is no cessation to the lifting movement or to its uniformity; that each bucket relieves the other of its load, alternately; and that the lifting speed is much more moderate than the inoperative return stroke. The pump location is also low, being but 9·28 feet above the well, at the centre.

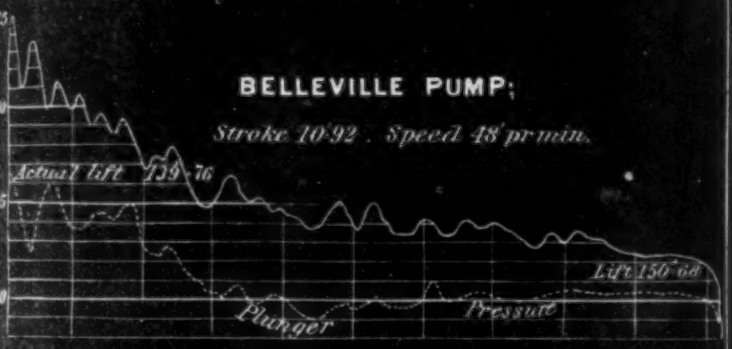
The card opens with a pressure of 61 lbs., as a wave of oscillation, which descends to 47·5 lbs., and then returns to about 53 lbs., from which during the stroke it gradually falls to 49 lbs. If we admit that a part of the oscillation is due to the momentum of the indicator piston, it cannot be claimed that this explains more than a portion of the evident wave as an effect of fresh impulse at the stroke commencement. The card clearly shows the distinct effort of each bucket to put its special charge in a certain motion, and the surplus initial power it is required to exert in order to accomplish this result, and it shows that the *vis viva* of this charge, reduces the load at the end of the stroke 4 or 5 lbs. less than the mean of the initiative motion, and

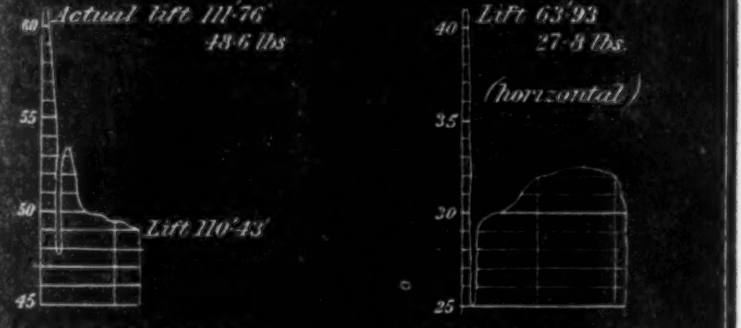
PUMP CARDS.

BROOKLYN ENGINE; Lower Pump



BELLEVILLE PUMP;





HARTFORD PUMP.
Stroke 16·12 in. Speed 21·92

CAMBRIDGE PUMP.
Stroke 26·17 in. Speed 33·3

about 10 lbs. less than the actual primary impulse. This settles the question of uniform velocity under eight sub-divisions of impulse, each traveling but 21·92 feet per minute, assisted by the resistance of a force-main contraction, and by an air chamber.

With two suction tubes of 16 inches diameter, the average load was 6·85 lbs. or 15·75 feet, while the actual average lift was about 9·28 feet, the variation during the lift being not less than 1 lb. in favor of the final load. The doctrine of uniform motion and load is then also at fault on the suction lift, and the pump location is demonstrated as in other cases described under the head of "Suction," to be too low. With such results as these in a typical arrangement, it cannot be contended that short continuous strokes, have any special value in uniform flow. Its advocates have no better resource than an improvement of the rotary pump. Nor is any proof furnished here of advantage in combinations of pumps.

As a second illustration of the effect of short stroke pumps, we give a card from the inner pump of the horizontal Cambridge double-acting engine, which was then making 40 strokes per minute. In this case, as noticed, the plunger acts through a central diaphragm. Here the initial effort to propel the charge carries the pencil up to 41 lbs. from which it returns at once to 25 lbs., thence to 30, rising at the first foot to 32, at the second to 32·5, ending the stroke at 30 lbs. The card shows a blow and a reaction, which is in part due to the engine arrangement, with light working parts, and with an annular cylinder of the Simm's pattern, in which a uniform steam pressure is attempted through combined high pressure and expansion; but the manner in which the initial effort is made, and its necessity, is nevertheless clear, as to the pump charge, as well as the absence of either uniform pressure or resistance.

Uniformly Variable Motion.—On the other hand, distinguishing between a supply-main in which the flow is maintained by the force of gravity, and a force-main in which impulse must overcome gravity, it is assumed that each particular stroke of a pump is, in a very important sense, an independent effort. This is true of all reciprocating movements to a greater extent than is generally supposed, and with regard to fly-wheel, steamboat, and locomotive engines, not less in principle, than in the direct-acting and non-rotary. Each particular stroke of the most perfectly balanced fly-wheel engine should contain a perfect measure of impulse and resistance, and the whole class of governors only illustrates the relative necessity and harmony of these conditions of motion, in which surplus initial impulse, and reduced final impulse, are unavoidable laws of each reciprocal piston movement.

In harmony with this principle it is also held, that it is impossible to disturb the equilibrium of the particles of a liquid like water, as of any fluid, by impulse, without producing a wave, which in the case of the stroke of a pump piston, becomes a wave of translation rather than of oscillation; this theory harmonizes with the natural tendency of water to undulation, under circumstances which peculiarly affect its large per centage of air, and develop its exquisite mobility, while its

gravity is being overcome, and avails itself of a law of common observation.

In brief, then, it is held, that each pump stroke at its commencement and earlier stages, imparts motion to a body of water equivalent to its charge, which charge has a natural tendency to produce a distinct wave of translation; that such stroke must exert a certain surplus impulse during a certain stage of its travel to create this wave, which surplus is compensated during the stroke in whole or in part, as proper circumstances admit, by the *vis viva* of the charge; that the maximum useful effect is determined by the smoothness with which this wave is created, and the facility with which its translation is accomplished, the power being transmitted at one period by an accelerating motion, which is retarded in completing the stroke; and that in a representative curve combining power and velocity, the greatest ordinate would precede the half stroke. It is also held that in every force-main there is a wave of maximum effect, which cannot be retarded, accelerated, or disturbed by irregularities of impulse without detriment, and defines a uniformly variable motion.

Under this theory, the pump area being adapted to that of the main, its length and speed of stroke become important; the former in order that all the benefits of impulse and *vis viva* may be attained, and the latter that the gradations of impulse may harmonize with the natural motion of the charge, during the effective part of the stroke. Too rapid an initiative is to be avoided on one hand to prevent concussion, and rapid acceleration from the initiative is to be secured on the other, avoiding all acceleration, after the wave has received its impulse, as waste of power. The ordinary mechanical doctrines of inertia, of impulse, and of momentum, have, in this theory, a simple and plain reiteration, and in its experimental results, a beautiful demonstration.

In the cards of the Belleville single-acting plunger, intermittent, and of slow speed in its stroke, and of the Brooklyn single-acting bucket, non-intermittent and rapid in speed, this principle of pulsation is effectually demonstrated. Standing on the reservoir bank of the Belleville heights, the bell-mouthed vent of the main is seen several feet above the usual water level. As the impulse is imparted from each pump stroke, a sheet of water rises with accelerating speed and pours over the level edge with a sound which defines its varying power, gradually dying away as the wave exhausts itself, and the lip of the vent becomes again dry; a process distinctly repeated with each pump stroke, at a distance of 2359 feet from the delivery valve, in a tube at the time unprotected by either air-chamber or stand-pipe. At the vent of the Brooklyn main, 3450 feet from the pump, these pulsations from the speed of flow and horizontal delivery, are less clearly defined, but may be distinguished by the ear, and at slower speed are more evident. Their law of motion is sufficiently evident from the card.

At Belleville, the counterweighted plunger detached, in one sense, from the cylinder, descends on its force lift. Its initial speed is slow and embarrassed, until its column is started, which is effected through the first third of the stroke, and then occurs the anomaly that although

its relative lift increases with its descent, its resistance actually decreases, from 65 lbs. at first, to 60 lbs. at 3·5 feet of its whole travel of 10·92 feet; we see also that the column has so effectually received its impulse that the delivery valve shuts down at 10·16 feet of the travel; so that the equivalent load at starting is 149·5 feet instead of 139·76, and at 10·16 feet descent it is 138 feet instead of 150.

The Brooklyn bucket commences its lift with a theoretical load of 163 feet, and an actual load of 174·8 feet, ending with a theoretical load of 153 feet, and an actual of 161 feet, the reduction in lift being about 10 feet, and the practical reduction 13·8 feet.

Here the maximum impulse has been imparted at about 3·5 feet of the stroke, the resistance rapidly diminishing after the 8th foot, and while this card illustrates the effect of a continuous application of uniformly variable impulse, as distinct from the intermittent strokes of the other, both cards show beyond question the law of motion due to each pump charge and its proper conditions of motion. The same law has been already demonstrated in the suction cards, given in the last number, wherein the Belleville pump shows a final stroke reduction of 7 lbs. from the maximum load, and the Brooklyn pump a reduction of 3 lbs. The aggregate effect shows, then, in the first case, a range of 12 lbs., and in the second of 9 lbs., between the initial and final parts of the stroke.

It is a matter of deep interest and importance to determine the conditions of area, speed, and length of stroke in pumps, as they are affected by these established mechanical and natural laws, and merits a serious and continued experimental research by the profession. Experiments with the Brooklyn pump indicate very clearly the connexion between a given speed and a maximum effect, and in time it will undoubtedly be demonstrated that every pump develops a uniform law of effect in these respects.

This wave of translation involves an effect which is erroneously claimed for the principle of uniform velocity, in facilitating and regulating the engine stroke. It is impossible that a strictly uniform motion should act as a fly wheel to an engine, since it would prevent that storing and rendition of power, from the commencement to the end of the stroke, essential to true reciprocal motion, under the law of mass in motion, by which cylinder expansion is attained. This wave, which in its formation receives the whole power of the initial impulse of the piston, in turn becomes an easement of the central and final portions of travel, preventing injurious concussions on one hand, while it relieves the terminal stroke on the other; a condition which is beautifully illustrated in the cards given, and especially in the action of the Batavia and Huelgoat pumps, and the large engines of the Haarlem Meer, and Brooklyn class. In single lifts of 754 and 1168 feet, the production of this wave is the key to harmonious action, and the very condition of safety. Precisely the same operation is true of the counter-weighted plunger on its steam lift, as Pole has demonstrated, and of every fly wheel, and of every steamboat wheel, as the crank-index of the splendid Sound steamer *Metropolis*, reiterates with every revolution. Uniform motion is a me-

chanical myth in practical dynamics and hydrodynamics. It is impossible for any pump piston to make a stroke without exerting at the outset a certain surplus pressure to overcome the inertia of its working parts and its charge, which it must be repaid during the stroke, to realize its maximum effect, and on the manner in which it exerts this surplus initial pressure, will depend its smoothness of action. The relative effects of crank and direct actions will be noticed in this connexion under another head.

Loss of Action.—From joint and valve leakage, presence of air, currents, and other causes, no pump will deliver its theoretical charge. Experiments on record show that this loss of action may reach a formidable extent, and it is obvious that perfection in construction as to lines of supply and delivery, valves, &c., and in operation, is important in this particular, as promoting the most complete charge to the pump chamber. Some Cornish plunger pumps show about 7 per cent. loss; those of the Pittsburgh class show 14·7 and 16·3 per cent.; the loss at Haarlem Meer is 10 per cent.; at Hartford, 6·5 per cent.; and at Brooklyn 1·65 per cent. These varied results illustrate the importance of correct workmanship and action, and in less perfect pumps probably range beyond 30 per cent.

It is contended by some hydraulic engineers, that the mechanical work of a pump is the same whatever may be its loss of action, and that the product of the pump diameter into the lift, measures the actual duty. We think it very plain, however, that the evident concussions shown on the annexed cards, are produced by the action of the piston in striking solid water, which virtually reduces the length of pump stroke and gives a certain travel without resistance; and it is also plain that the only resistance to the leaky portion of the piston is that due to the friction of the lost current in passing it, on the perimeter of the leak. If the piston were to leak the entire pump charge, the delivery valve would remain on its seat, and the engine load would be represented by the piston friction alone, and whatever part of the pump is unfilled certainly prevents effective travel.

Combined Pumps.—Among other processes for attaining uniform delivery, it has been customary to combine several pumps with a common main, and with varied centres of motion. Some very curious devices of this kind have been strongly urged, and occasionally put in operation. It is evident, however, that if each pump stroke has its distinct acceleration and retardation in generating its wave of translation, that a discharge into the same main, of a second, third, or fourth wave, under different times of impulse, must produce injurious counteractions. These are unavoidable in all such combinations, and are sources of direct loss of power, which experiment has clearly defined. In the case of blowing engines, and other connected stationary engines, as in the case of steamer engines, of which the Great Eastern is a notable example, one engine is always operating at the expense of the other, to a certain extent, defined by the mutual conditions of impulse and resistance.

In one extreme case which has come under our observation, the ad-

dition of a second steam pump to a force main, has increased the total delivery less than fifty per cent., while the coal account was fully doubled, and we have notes of experiments on large engines, where an increase of fourteen per cent. in load is directly attributable to this counteraction.

Force Main.—This should be laid, as to diameter and directness of line, on the most liberal scale admitted by the standard of supply and demand, already referred to. The friction, which diminishes nearly as the square of the velocity of flow, is directly modified by increase of diameter, and also varies with the length, representing a constant co-efficient of work, which must be covered in the coal account. The relative friction, however, of a well arranged main is not a formidable item by any means, generally much overrated in engine house locations.

All horizontal bends are to a certain extent objectionable, though much less so than vertical bends which permit the accumulation of compressed air, always a formidable resistant to water flow; contractions and expansions in form are also objectionable, as are all check-valves, although occasionally indispensable.

The experimental observations on force-main friction show the interesting fact that the formulæ determined for a fixed head and uniform discharge by the various authorities in hydrodynamics, are sufficiently applicable to the conditions of motion which have been presented, to warrant a full reliance on their correctness, and to demonstrate in certain cases an accuracy, with which they are sometimes discredited. The Brooklyn mains, of which one is connected with each engine, are 3 feet in diameter, 3450 feet long, laid without vertical bends, with one curve of 800 feet radius, with two check-valves, and a conical adjutage. With a mean flow of 180 feet per minute, the actual loss of head is 4·71 feet; while the theoretical loss by the simple and elegant formula of Weisbach is

$$H = \cdot 0244 \frac{3450}{3} \frac{3^2}{64 \cdot 4} = 3 \cdot 92 \text{ feet,}$$

leaving 0·79 feet to be accounted for in check-valve and curve friction. This not only demonstrates the formula, but it indicates the law of motion of the pumps and tube, on the most powerful scale in the history of pumping engines, each of these engines being by some 21 per cent., the most powerful in use. Other cases exist, however, in which imperfect construction and action, give the formula a negative endorsement, which is valuable as a lesson.

The value of an air-chamber as a cushion to the pump stroke and main flow may be very strongly urged; its elasticity is perfect and its operation conclusive; and yet by a misapprehension of the original uses and purpose of the stand-pipe which specially belongs to the intermittent supply system of the European school, it has become customary with us to adopt a modification of it, in which the overflow is not used as in the old country, and a very rude, cumbrous, expensive, and inexcusable appendage is substituted for the convenient and effective-air chamber.

(To be Continued.)

For the Journal of the Franklin Institute.

The Burlington Tunnel. By S. HUNTINGTON, Jr., C. E.

The Burlington Tunnel may be called an anomaly among tunnels. It has a single track only, but the peculiar nature of the earth in which it is built, and the novel and ingenious mode of its construction, renders it something of a curiosity among works of this class. It is situated at Burlington, Vermont, on a portion of the Vermont and Canada Railroad recently constructed.

Earth Formation.—The road, at the point where the tunnel is situated, enters a high ridge whose top is about one hundred feet above the interval lands which lie on the east side, one hundred and twenty feet above the lake, on the west, sixty feet above the top of the tunnel, and twelve hundred feet wide. The earth, of which this is composed, is entirely of sand of different degrees of fineness varying from the finest quicksand to coarse gravel. It is arranged throughout the lower portion of the ridge in unsymmetric strata having a general inclination of 15° to the horizon. These strata have the appearance of at sometime having been thrown up by the action of waves, and their contiguity to the lake, renders such a supposition extremely probable. Their nature entirely agrees with the earth contained in the upper portion of the ridge, viz: that of *loose, shifting sand* with a natural slope of 30° with the horizon.

Description.—The longitudinal form of the work is probably not very dissimilar to the generality of works of this class. It descends on a grade of 1 foot in 400 feet throughout its extreme length, and is curved with a radius of 1433 feet (4°). The ends are surmounted by high revetment walls extending above and on each side of the roadway.

The transverse section resembles very much a horseshoe in shape, being a combination of arcs of circles of different radii.

The arch and side walls are of brick which rest on skew-backs of cut limestone. The foundation and between walls are of concrete masonry.

DIMENSIONS.	ft.	10ths.
Length of tunnel on the centre line,	340	
" " outer side of curve,	342	2
" " inner " "	338	6
Depth of top (extrados of arch) below the surface,	60	
Height of intrados above the grade line,	18	5
Breadth of tunnel at " "	13	
" " widest part (8 feet above grade),	16	
Thickness of the arch and side walls,	2	
Height of revetment walls above the extrados,	20	
" side " "	38	
Length " " "	45	
Thickness " "	3	

Drainage.—The nature of the earth through which the work passes, is such as to dispense with the necessity of any drains along the bottom or top of the tunnel. At the foot of the slope, above the top and against the revetment walls, a ditch of cemented paving is placed, to

receive the water shed from the face of the excavation, and connected with cast iron tubes at each extremity. These tubes pass through the wall, and on the face of the side walls another ditch, of the same material, is placed, connecting the mouths of these tubes with the side ditches.

Construction.—In order to form a basis from which to commence driving the heading, and to protect the face of the work while in the process of construction, from the sliding in of the surrounding sand, thus materially retarding the work, large timber shields were constructed surrounded on three sides by planking. These shields were first placed on the surface of the ground above their intended position, and the excavation commenced by steps, the shields, being gradually undermined, sinking slowly as the excavation proceeded, until they reached their required position on a level with the proposed work.

After these shields had been properly braced and otherwise prepared, the heading was commenced. On the face of the excavation a stick of timber, or *chord*, 21 feet long, (6 ins. × 8 ins.) was placed about 15 feet above the bottom of the excavation, and perpendicular to the line of the road. Upon this chord a segmental arch of wood seven feet high was placed, made of spruce boards bolted firmly together. The centre of the arch was supported from the chord, by a heavy post, and smaller pieces radiated to its different points. The ends and middle of the chord were supported in position by other posts. A hole was then bored, with an augur $2\frac{3}{4}$ inches in diameter and 7 feet long, over the middle of the arch and in the direction of the tunnel, making an angle of about 5° with the horizon. In this hole was driven a spruce arch-piece 8 feet long, (3 ins. × 3 ins. cross sect.) pointed at one end. On each side of this arch-piece holes were bored in the same manner as the first, and similar pieces driven as close as possible to the first, so they would touch, the object being to form a complete wooden arch. Other holes were continued to be bored, each side of these last, and other pieces inserted, until the arch was completed. This first arch having been completed the excavation of the heading was commenced. It was carried forward until there was danger of undermining the unsupported ends of the arch-pieces, (about 3 feet) when another arch was erected. This second arch was erected in the same manner as the first, excepting that the chord was supported by the bottom of the heading. Between the top of the second arch, and the arch-pieces of the first, a space of about 6 inches was left open. This was filled by wooden wedges driven in with great force, in order to give the first arch a firm bearing on the second centre. The excavation was then continued for another 3 feet, when another arch was constructed in like manner.

When the heading had proceeded about twenty-five feet, the excavation of the bottom was commenced. A narrow perpendicular trench was first dug immediately under the middle of the second chord, temporary props being placed to keep it in position, and a strong post (10 in. in diameter) placed in it with one end resting on a thick plank, and the other supporting the chord. Similar trenches were then dug under each extremity of the chord, and other supporting posts, as the

first, placed in position. The excavation of the earth was then commenced, and proceeded until there was danger of undermining the second chord, when the same operation of placing supports, &c., was gone through with. As fast as the earth was removed, thick planking was placed outside of the supporting posts, on each side, for the purpose of retaining the earth in its proper position, and, on account of the great lateral pressure, braces stretching from the centre, to the side-posts along the bottom, were used.

The space thus excavated was a little larger than the required size of the exterior of the arch and side walls. The next thing done was the laying of the foundations; this was accomplished by digging trenches on each side, in the proper position for the foundation of the side walls, three feet deep, and filling them with concrete masonry. Upon this concrete foundation were placed the skew-backs, which were of dressed limestone. Large centres over which the arch was to be built, were then constructed capable of supporting both the arch and the surrounding earth. The masonry of the side walls and arch was then commenced, and carried forward in three sections of twelve feet in length each. As fast as each of these sections was completed, the wooden centerings over them supporting the temporary wooden arch, were removed and the supporting posts cut away. There then remained a considerable space between the extrados of the finished arch and the intrados of the temporary wooden arch. This was filled with sand taken from the upper heading, rammed hard with heavy beaters. After this had been done the centres were removed, and the arch left to do its designed work.

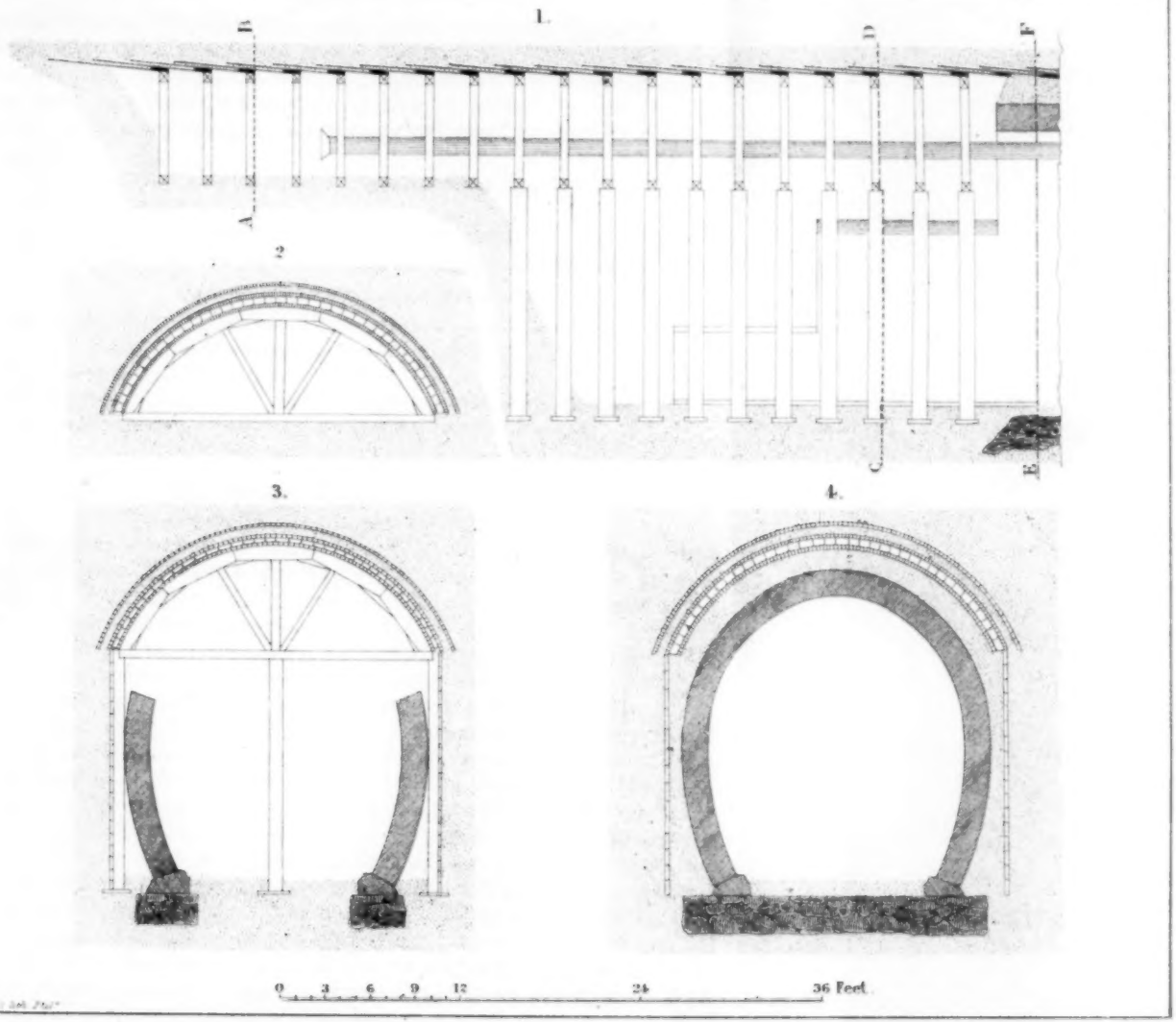
Eighty-five men were employed in its construction, one-half for the day, and the other half for the night work. The number of men employed in driving the heading was eight, one-half engaged in driving the arch pieces, and the other half, in constructing and setting up centres. The heading was carried forward both day and night; but in order that the passage of the cars, conveying the material away, might not interfere with the masons, the lower portion of the excavation was worked only by day, and the masonry constructed by night.

As the heading advanced it was found that the foul air collected in that part of the tunnel, and, to remove it, a pipe one foot in diameter was constructed, extending from the upper heading, through the tunnel to a chimney at its mouth, around whose base a fire was kept constantly burning, to secure a draft.

Heat was secured (the work being carried forward principally during the winter) by means of large stoves. Light was furnished by a small gas apparatus, which lighted the tunnel and about twelve hundred feet of excavation.

The progress of the heading was about three feet daily, averaging about fifteen or sixteen feet per week. The lower excavation and supports were much slower.

Remarks.—About thirty feet from the west end of the tunnel (the part last built) a crack has appeared in the masonry, about two inches wide at the top and gradually diminishing as it extends down the sides



apparatus has been adopted on both sides of the tunnel, and the work progresses daily at the rate of four or five feet. Still, it is evident that ten years will hardly suffice to complete the work. The cost of this gigantic undertaking is estimated at sixty millions of francs, but

Remarks.—About thirty feet from the west end of the tunnel (the part last built) a crack has appeared in the masonry, about two inches wide at the top and gradually diminishing as it extends down the sides

to the bottom. Through this, water keeps constantly dripping, which leads us to think that it was caused by the disintegration of the mortar by water, showing the want of proper care in its preparation. It has been in a measure remedied by sinking a shaft to the extrados of the arch, and placing drains to carry the water entirely off from the masonry.

The entire time employed in the construction was one hundred and ninety-one days.

Six hundred and eighty thousand feet of lumber was used.

The contract price of the work was sixty thousand dollars.

EXPLANATION OF FIGURES ON PLATE III.

Fig. 1—Represents a longitudinal section of the work as it appeared when in the process of construction, showing ventilating pipe.

Fig. 2—Shows a section on A, B.

Fig. 3—Shows a section on C D with side walls in process of construction.

Fig. 4—Represents a section of the tunnel when completed, as on E, F.

The Tunnel through Mount Cenis.

From the Lond. Civ. Eng and Arch. Jour., Oct., 1862.

The great enterprise of Sir Isambard Brunel of constucting the tunnel under the Thames, has nowhere been imitated on such a gigantic scale as in the case of the tunnel through Mount Cenis, which will open a new and shorter communication between the North of Europe and Italy. It is, in fact, such an undertaking as could hardly have been ever achieved if some recent mechanical and engineering improvements had not come to its aid. The entire length of this tunnel is estimated at about 12,220 metres. Its situation is between the railway station of Susa and St. Jean de Maurienne, west of the present highway from Susa over Mount Cenis by the Col de Fréjus, at an elevation of 1338 metres or about 4100 feet above the level of the Mediterranean. The Southern opening of the tunnel lies about 6½ leagues west of Susa, near the hamlet of Bardonèche: hence the tunnel ascends by a gradient of ½ per 1000 until the middle of the mountain, and then descends towards the northern opening of the tunnel, near the village of Mondone, with a gradient of 23 per 1000. On account of the great height of the mountain, no vertical shaft was possible. The present postal road passes Mount Cenis at an elevation of 6354 feet, and the height of the Col de Fréjus is 9168 Paris feet, or 2978 metres.

This stupendous work was began on the 31st of August, 1857. At the present moment the excavations extend to 740 metres on the north, and to 950 metres on the south side, and consequently 10,530 metres are yet to be bored. Up to a late period the mining operations were performed by the ordinary method of manual labor, but now new boring apparatus has been adopted on both sides of the tunnel, and the work progresses daily at the rate of four or five feet. Still, it is evident that ten years will hardly suffice to complete the work. The cost of this gigantic undertaking is estimated at sixty millions of francs, but

probably this sum will be much exceeded. France has to contribute twelve millions of francs, but has not done so hitherto. If present circumstances continue, it is to be feared the works will be stopped.

The work of boring is done by machines, which are moved by air compressed by hydraulic pressure. The water necessary for this purpose is obtained in the following way. The water which constantly pours down the slopes of the Alps, and which forms the chief supply of the little river of Bardonèche, is collected in channels and large reservoirs, and thence conducted by long tubes to a building, in which there are ten iron tanks in the shape of steam-boilers, each of which is furnished with a vertical tube of two feet in diameter and fifty metres high. While the water is conducted from the main tube into these ten secondary ones, the air is conducted by a ventill apparatus, of which each tube has one, the air and water is so conducted that the tanks are completely filled with air, and the tubes with water. The columns of water in the tubes now compress the air, with a force of 22,000 lbs., which causes the air to issue from the reservoir with great force. A strong metallic tube eight or nine inches wide is conducted into the tunnel, close to the boring apparatus, where four tubes of india-rubber, secured by screws, bring it in four cylinders placed horizontally, from whence the rotary apparatus, which moves the boring instrument is fed. This rotary apparatus moves eight steel gimlets, each three feet long, which placed at an angle of 45°, penetrate, pushing and boring into the rock. As the borers make 200 strokes each minute, the noise is terrible. The air cylinder, the borer, and the men at work are placed on an iron framework, which can be moved upon wheels rolling on iron rails. Ventilation, as well as the removal of dust, is effected by the opening of spiral air valves fixed on the iron tubes. The boring apparatus, made at the manufactory of Cockerill at Sèraing, are 9 feet long by ten to twelve inches high. Each machine perforates the rock, according to its solidity, to the depth of 2 ft., and a width of 1½ inch. On each surface of 6 square metres, four holes, 2 feet long and 3 inches wide, and seventy or eighty holes of the same length, but of less width are made. After all the holes have been drilled, which generally occupies six hours, the iron framework, with the boring apparatus, is drawn backward in the shaft about 100 metres, and it is closed by a strong wooden gate, for avoiding the projection of stones when the mine is exploded. The method resorted to here, is the usual one of gunpowder and a conducting train, but the four large holes in the middle are not loaded. After the firing of the mine the smoke of the gunpowder is expelled by means of the ventilating apparatus, and the debris of rocks carried in small carts, on a lateral rail, to the large wagons at the entrance of the tunnel, and thence conveyed to the general repository of rock debris. The collecting and removing the rock debris takes also six hours, and thus the blasting can only be done twice a day. There are two rails in the tunnel, between which is a conduit for the efflux of the water. It is altogether supported by a vault, that at the north end made of hewn stones, on the south side of bricks. Outside are the reservoirs and the build-

ing for the machines to compress the air, a mechanical workshop furnished with a turbine, a large building for the officers, and a manufactory of gas for lighting the tunnel and the buildings.

The Economic Construction of Girders.

From the Lond. Civ. Eng. and Arch. Jour, July, 1862.

(Continued from page 319.)

3.—*Calculation of the Stresses on the Large Experimental Girder,* in experiments numbered I., III., and IV., in which the Girder failed by the rending of the bottom.*—We have noted that Mr. Clark derives from the results of these experiments a measure of strength which we have denoted by the letter Q, and which approximately gives the total tensive moment in terms of the sectional area of the bottom, and its depth below the neutral axis; and is therefore only applicable to girders having sides, top, and bottom all exactly in the same proportion one to another; so that the last experiment, or No. IV., is the only one having the appearance of being at all useful in this form. We therefore propose calculating the actual stress per inch on the extreme fibres in each of the experiments, so as to render them all to some extent valuable.

Diagram 3. showing the plates, and angle-irons in half of the mid-span section of the Experimental Girder, 75 feet span.

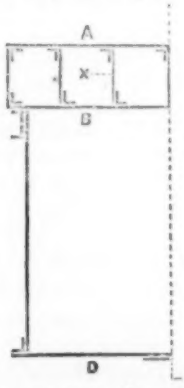


Diagram 4.

When we come to the actual calculation, we are unfortunately met by some discrepancies as to the dimensions of the parts. Thus on page 160, the information given in the upper half does not tally with

* It is too much the custom to represent a load at the centre of a girder as equivalent to twice that load spread uniformly over the span. It is so only as regards the longitudinal stresses at the mid-span, in so far as these are not affected by the stresses induced in the web. But in all other directions the effects of these loadings differ very materially: and therefore the one cannot be correctly substituted as a test in place of the other. But let us confine ourselves to the question as regards the model tube (we may leave out of consideration the weight of the tube itself). When a test-load is placed on the mid-span, the whole length of the web is nearly equally subjected to certain oblique compressions and tensions occupied in transferring from the midspan to each pier half of the central load. By a correct test-loading, or one of double the former amount, spread uniformly over the girder, the stresses in the web are very different, the part at the mid-span is nearly free from stress; but the parts near the supports are stressed to *double* the degree caused by the former load. The experiments cannot, therefore, be accepted as a proper test of the strength of the web, they overstrain it at the mid-span, but only apply half the proper stresses to its extremities.

the measurements used in the estimates at the lower half; and the angle-irons, which are stated in pages 158–59 to have sectional areas of ·175 and ·325, are in the estimate made equal to the sum of the sides multiplied by these values, as mean the thicknesses; this again cannot be accepted without doubt, since Fig. 2, on page 159, shows an average thickness of the stronger angle-iron equal to 0·2 instead of 0·325. It is therefore with very little confidence in the correctness of the following dimensions that we proceed to calculate the stresses. As, however, the total sectional area of the girder appears to be not very far wrong, being checked by the test of weighing, we will correct the side areas at the expense of the top.*

Let the various plates, with their attached angle-irons, be supposed to become concentrated in their central lines on the same principles as described for diagram 2, of the Conway tube; this is shown by diagram 4.

The dimensions are A D = 4·530; X D = 4·275; B D or $h_{\text{I}} + i = 4{\cdot}015$; AB or $h_{\text{II}} - i = 0{\cdot}515$. The sectional areas are assumed to be, A plates = 8·7; B plates = 8·7; X plates = 6·0; sides, $4{\cdot}015 \times 2 \times 0{\cdot}1 = 9{\cdot}636$; D plates = 8·8 in Experiment I_{D}, = 12·8 in Experiment III_{D}, and = 18·31 in Experiment IV. From these we are enabled to calculate the positions of the neutral axis, and hence the following values of h and i.

In Experiment I.	$h_{\text{I}} = 2{\cdot}854$	$h_{\text{II}} = 1{\cdot}677$	$i = 1{\cdot}161$
" III.	$h_{\text{I}} = 2{\cdot}605$	$h_{\text{II}} = 1{\cdot}925$	$i = 1{\cdot}410$
" IV.	$h_{\text{I}} = 2{\cdot}325$	$h_{\text{II}} = 2{\cdot}205$	$i = 1{\cdot}690$

The formula for the moments of the compressions will be the same as obtained for the Conway, viz.,

$$= c \left\{ \text{A}h_{\text{II}} + \text{B}\frac{i^2}{h_{\text{II}}} + 4bi\frac{i^2}{h_{\text{II}}} + \text{X}\tfrac{1}{3}\left(h_{\text{II}} + i + \frac{i^2}{h_{\text{II}}}\right) \right\}$$

and for the parts under tension the moments are simply $= e\text{T}\,(dh_{\text{I}} + 4bh_{\text{I}}^2)$. Substituting in these formulæ the values given above for the factors, we get in Experiment I. the total moment of the section = $e\text{T}\,49{\cdot}023$; in Experiment III. the moment of the section = $e\text{T}\,65{\cdot}107$; and in Experiment IV. the moment of the section = $e\text{T}\,87{\cdot}278$.

In the three experiments the equivalent distributed loadings, that is, the weights of the girder added to double the central breaking weights, are respectively = 76·175 tons, 118·053 tons, and 137·948 tons. And the moments of these loadings at mid-span are respectively = 714·1, 1106·74, and 1293·26. Equating these moments with those obtained for the sections, we arrive at the values of the stresses, which are as in Table III.

TABLE III.—*Stresses on the Experiment Girder.*

	eT.	T when e=·85.	c.
Experiment I.	14·567	17 138	8 559
" III.	16·999	20·000	12·562
" IV.	14 818	17 433	14·053
Average,	15·461	18 190	

*In the estimate of the top, at page 160, the attached *arch* of angle-iron is omitted, and *overlaps* are included which do not appear in the detail drawings. (See Dr. Fairbairn's 'Narrative.') Further the thicknesses of the plates A and B, which are given in the upper part of the page as ·179 and ·151 appear respectively as 0·151 and 0·153 in the estimate. As to the side plates, their depth is 4 feet not 3′ 9″ as in the estimate. Their sectional area is correctly given as =9·6 at page 163.

18·2 tons is then the absolute tensive strength of the plates calculated on the suppositions embodied in the above principles. Why this is less than the ultimate strength obtained by direct experiment (see page 376, where this is given as varying from 18 to 22 tons, with an average of about 19·6) may not be beyond explanation. The value assigned to e may be too high; if we take it $= 0{\cdot}8$, that is, suppose one-fifth of the whole section to be destroyed by the rivet-holes, T comes out $= 19{\cdot}326$. But there is a cause at work which we will endeavor to explain. The sides or webs of all such girders and tubes must necessarily have an inferior ultimate tensive strength against a stress in the direction of the length of the girder, on account of the inferior character of the riveted joints and the direction of the fibres of the plates; we may, however, assume them to be equally *stiff* with the bottom. The consequence will be, that the sides and top will only work harmoniously together up to the point at which the stress in either of them attains the ultimate value; so that in cases like this experimental girder, wherein the side plates descend to nearly as low a level as the bottom plates, rupture will begin at the lower edges of the side plates considerably before the plates of the bottom have given out their full strength. And if we suppose the lower edges of the side plates to be exactly at the same level as the bottom of the girder, their failure will begin when the bottom plates are stretched to an extent corresponding with the ultimate stretch and strength of the side-plates; and—unless the bottom plates be of such large sectional area, that the 3 or 4 tons per inch more of strength that they may put forth after failure in the sides has begun, will more than make up for the loss of the strength previously given out by the side plates—complete rupture will ensue. If, as we have supposed, the elasticities be exactly the same for bottom and side plates, let h be the extreme distance of the bottom from the neutral axis, and m equal to the distance from that axis of the point to which the sides become split up when the bottom attains its greatest elongation; then, if $e\mathrm{T}$ and $e_1\mathrm{T}_1$ be the respective ultimate resistances to tension of the bottom and sides, we have when the bottom is fully stretched $m = \frac{e_1\mathrm{T}_1}{e\mathrm{T}}h$, so that when the full value of $e\mathrm{T}$ is counted upon, the tensive movements will be $= e\mathrm{T}$ (section of bottom $\times h +$ thickness of sides $\times 4\frac{m^3}{h}$), m and h being measured in feet and the areas in inches. In addition to the above causes of weakness we have the slight warpings and irregularities unavoidably produced in riveting up such thin plates, which must tell against the general tensive strength.

It will now be obvious that no very direct use can be made of the experiments in helping us to the value to be assigned to T for the Conway, but as some of the prejudicial causes noted above will also be present in some degree in the case of the Conway tube, we may be allowed to assign a value to T slightly less than that obtained from

the direct experiments upon the plates used in its construction. Let T, then, be taken = 19 tons, instead of 18·2 as derived from the experimental tube, or, of 19·6 from the direct experiments on the uninjured plates.

So that, when the Conway is loaded at the rate of one ton per foot run, and the same factor of safety is employed for movable as for fixed loading, that common factor will be = 19 ÷ 7·18 (Table II.) = 2·65 only; and if the factor for movable load be taken equal to $1\frac{1}{2}$ times that for fixed, we have the respective factors equal to 3·506 and 2·337.

These factors are very unsatisfactory. But the correct factors, which must be obtained after allowing for the effects of the wind, are still more so. We now proceed to calculate the additional stresses produced thereby.

4.— *The Stresses produced in the Top and Bottom of the Tube, by the lateral pressure of the Wind.*—By the lateral pressure of the wind one side of the tube is thrown into a state of tension (compared with its normal condition), and the other into a state of compression. It does not appear to have occurred to those investigating the question that the edges of the top and bottom of the tubes participate, to the full extent at least, in these stresses; and that the wind-induced stresses must therefore be added to the previously existing stresses produced by the action of gravitation. And the greatness of this addition can, we think, never have been calculated. Mr. Clark does not give any such calculation for the Conway tube, misled probably as to its importance by a serious error that occurs in that for the Britannia tube at page 787. The investigation there given is correct enough in principle, the error occurs in the final arithmetical operation; he gives the formulæ $\frac{\mu z}{f} = 0{\cdot}621$, wherein μz expresses the total pressure of the wind on one side of the tube = 120 tons, when the force is taken at only 20 lbs. per superficial foot; f = the stress per square *foot* induced on the material of the sides; we consequently have $f = \frac{\mu z}{0{\cdot}621} = \frac{120}{0{\cdot}621}$ = 193·4 tons per foot = 1·34 tons per inch. Mr. Clark makes this = 74·5 tons per foot or about half a ton per inch. Now when we consider that the sides are not very well suited to withstand either tension or compression in the direction of the span, it is apparent that the edges of the top and bottom will receive more than their just shares of the total stress, that is, there will be more than one-and-a-third ton per inch to be added to the previously existing tension on the leeward edge of the bottom, and to the compression on the windward side of the top. The fact of the windward edge of the bottom being relieved of tension to the same extent does not affect the question as regards the leeward edge, the stress from gravitation being brought upon it by that side of the tube to which it is attached, quite independently of the other. Furthermore, 20 lbs. must be looked upon as an under-

estimate of the force of the wind, allowance should be made for the effects of suddenness of application, or even for the possibility of the gusts being isochronous with the lateral oscillations of the tube. At page 470, indeed, we find the pressure estimated at 46 lbs. per superficial foot, and in Dr. Fairbairn's "Narrative," at page 120, 50 lbs. is the estimate; of course the stress to be added will be in proportion to the pressure per foot, at 50 lbs. the stress would be = 3·35 tons in the Britannia tube, according to Mr. Clark's own formulæ quoted above, which however does not take into consideration the modifying effects of continuity past the piers.

Let us now investigate the stresses occasioned in the *Conway* from the lateral action of the wind. Let F = the force of the wind in lbs. on each superficial foot. The tube being three feet deeper at the centre than at the ends, the pressure is more serious than if uniformly spread over the length; to have the equivalent uniform load we must somewhat increase the area. The actual area, omitting the roof, is = 400 feet × 24·5; let us take it equal to 10,000 feet, we have then for the moment of the wind pressure,

$$\frac{10{,}000\ \text{F} \times 400}{8} = 50{,}000\ \text{F lbs.} = 223{\cdot}21\ \text{F tons} \qquad (5)$$

To resist this, we have,

$e\text{T} \times 14{\cdot}667$ (area of one side + ⅓ areas of top and bottom) (6)

And taking the areas from page 589, and equating the moments, we have,

$223\ 2\,\text{F} = e\text{T}\,(128{\cdot}5 + 196{\cdot}8)\ 14{\cdot}667$, whence $e\text{T} = \text{F} \div 21{\cdot}34$ (7)

But from the inferior quality of the riveting of the sides, a low value must be taken for e, say = 0·75, so that

$$\text{T} = \text{F} \div 16 \qquad (8)$$

When F = 20 lbs. per foot, T = 1·25 tons per sectional inch.
" F = 30 lbs. " T = 1·875 " "
" F = 40 lbs. " T = 2·50 " "
" F = 50 lbs. " T = 3 125 " "

By adding these results to those given in Table II. we arrive at a near approach to the actual stress, to which the leeward edge of the bottom of the tube is subjected under the given circumstances of wind and load. Thus, with a loading of one ton per foot run, and the effect of the wind taken as equivalent to 30 lbs. per foot, we have the tensive stress on the solid inch of iron = 7·178 + 1·875 = 9·053 tons, or half of what we have been led to consider the ultimate strength of the plates.* And this result it must be borne in mind, is obtained with an over-estimate of the efficiency of the angle-irons and an under-estimate of the span and loading. It does, then, appear, that the stresses greatly exceed what has been considered the limit of safety, namely, from five to six tons of tension, and considerably less of compression: it is therefore with some earnestness that we would press upon the consideration of those entrusted with the care of the structure the propriety of employing the means which the connecting of

* On the windward side of the top the addition would tell still more unfavorably.

the pair of tubes together offers of alleviating in some degree, this serious excess of stress.

5. *Connecting the Tubes together as a means of Diminishing the Stresses from the Wind.*—The connexion of the tubes together may be carried out in two different ways. The least perfect of these is by the simple introduction of struts between them to retain them strictly parallel, so that the leeward tube will assume the same amount of lateral curvature as the other, and so take on itself half the duty of resisting the wind. This arrangement would reduce the foregoing tension from 9·053 to 8·116 tons, supposing that the wind takes no hold on the second tube.

But the more perfect way of connecting the tubes is by introducing between them efficient systems of horizontal bracing, thus rendering the whole structure as it were one girder nearly 38 feet deep, to resist the lateral pressure: by this means the stress per inch produced by the wind, calculated approximately, will be less than one-fifth of that on the windward tube when unconnected; or the total stress above given as 9·053 in the unconnected tube is reduced to about 7·511 tons—a reduction so evidently necessary and important as not to need any further insisting upon on our part.

(To be Continued.)

Railway Statistics in Great Britain.

From the Lond. Builder, No. 1026.

An average day's work of the railways of the United Kingdom in 1861 was, to carry 500,000 passengers, 258,000 tons of minerals and merchandise, 35,000 live stock, 1100 dogs, and 740 horses. The precise number of travelers of the year cannot be stated, because there is no record of the journeys of season ticket-holders; but it must have been more than six times the number of the population of the United Kingdom. The *Times* gives some curious statistics. Thus: The trains, passenger and goods trains added together, traveled 2,897,748 miles more in 1861 than 1860, which is equivalent to going round the world 116 times more last year than in the year before. 3,881,990 trains ran in the course of the year; that is to say, upwards of 10,600 a day, or more in a day than seven times the number of minutes in the day. If the trains had been equally distributed, running night and day without ceasing, they would have traveled among them 200 miles in every minute. The length of the line open increased by 436 miles, and became 10,869 miles; and the gross receipts of the year, £28,565,355, considerably exceeded the interest of the national debt, and amounted to 8 per cent. on the capital. The total raised by shares and loans increased from £348,130,127, at the end of 1860, to £362,327,338; an increase of more than £14,000,000 in the year. The working expenditure rose to above 48 per cent.; and the net receipts only increased by about £130,000, or less than 1 per cent. on the increase of capital. The net receipts were rather over 4 per cent. on the capital.

It appears from a Parliamentary return, recently issued, that in the year ending December last, the Eastern Counties Railway, including by that term all the lines now combined under the title of "Great Eastern," had 1,290,278 first-class passengers; 2,441,575 second-class; 6,133,679 third-class, including Parliamentary. The number of holders of season tickets was 1647. The number of passenger trains was 118,680, and of goods trains 52,312. The total receipts from all sources of traffic were, £1,394,114. The third-class passengers, as usual, produced the most money. The receipts from them were £257,726, from second-class, £209,069, from first class, £169,294, and from season tickets, £18,235.

For the Journal of the Franklin Institute.

Problems on Open Built Beams. By D. Wood, M. A., Prof. of Civil Engineering University of Michigan.

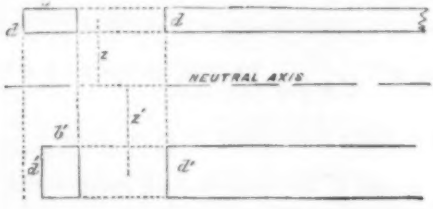
In hollow beams we assume that the strains upon the fibres follow the same law as in the solid beam, viz: that the strains are proportionate to the distance from the neutral axis. We also assume that the neutral axis is at the centre of gravity of the section. I propose to apply the same principles to a few problems of open built beams, which is equivalent to neglecting the vertical web of a hollow beam, or double **T**-beam.

On this hypothesis I propose to show:

1st. That the equivalent depth is usually less than the distance between the centres of the sections.

2d. That one of the chords may be so much smaller than the other as to make the whole girder less strong than the large chord alone.

3d. When the resistances of compression and tension are equal, the chords will be of equal size only when the breadths or depths are equal.



Let

b = Breadth of upper chord.
d = Depth " "
b' = Breadth of lower chord.
d' = Depth " "
D = Distance between the centres of the section.
z = " " centre of the upper section and the neutral axis.
z' = Distance from the neutral axis to the centre of the lower section.
R = Modules of strain for compression and R' for tension.
I = Moment of inertia.

To find the centre of gravity of both sections, we have from mechanics:

$$b\ d\ z = b'\ d'\ z';\ \text{Also } z + z' = D.$$

$$\therefore\ z = \frac{b'\ d'}{b\ d + b'd'}\ D. \qquad z' = \frac{b\ d}{b\ d + b'\ d'}\ D. \quad . \quad . \quad (1.)$$

The moment of strain of the upper chord is, from the well known formula:

$$R\frac{I}{z + \frac{1}{2}\ d} = R\frac{\frac{1}{3}\ b\ (z + \frac{1}{2}\ d)^3 - \frac{1}{3}\ b\ (z\ \frac{1}{2}\ d)^3}{z + \frac{1}{2}\ d} = \frac{R\ b\ d}{z + \frac{1}{2}\ d}\left(z^2 + {}_1{}^1{}_2\ d^2\right)$$

Similarly for the lower cord $= \frac{R'\ b'\ d'}{z' + \frac{1}{2}d'}\left(z'^2 + {}_1{}^1{}_2\ d'^2.\right)$

Hence the total moment of strain is

$$M = \frac{R\ b\ d}{z + \frac{1}{2}\ d}\left(z^2 + {}_1{}^1{}_2\ d^2\right) + R'\ \frac{b'\ d'}{z' + \frac{1}{2}\ d'}\left(z'^2 + {}_1{}^1{}_2\ d'^2.\right) \qquad (2.)$$

But, $\frac{R}{z + \frac{1}{2}\ d} = \frac{R'}{z' + \frac{1}{2}\ d}$; hence (2) becomes

$$M = \frac{R}{z + \frac{1}{2}\ d}\left[b\ d\left(z^2 + {}_1{}^1{}_2\ d^2\right) + b'\ d'\left(z'^2 + {}_1{}^1{}_2\ d'^2.\right)\right] \qquad (3.)$$

If the strain become so great that R or R′ becomes the modules of strength, then the *strength* of the beam is still determined by equation (3), observing that of the two fractions $\frac{R}{z + \frac{1}{2}\ d}$ and $\frac{R'}{z' + \frac{1}{2}\ d'}$, the smaller must be used.

Thus if the resistance to compression equals that to compression, or $R = R'$, then the denominator must be the greater of the two quantities $(z + \frac{1}{2}\ d)$ and $(z' + \frac{1}{2}\ d')$.

If the resistance to compression is twice that for tension, or, $2\ R = R'$, then will $\frac{R'}{z' + \frac{1}{2}\ d'}$ be used, unless $z + \frac{1}{2}\ d$ is twice as great as $z' + \frac{1}{2}\ d'$; if it is more than twice as great then $\frac{R}{z + \frac{1}{2}\ d}$ is used.

The values of R and R′ for tension and compression are found by experiment, and entered in tables.

In the remainder of this article I shall assume that R and R′ are equal to or proportional to their ultimate resistances.

If $b = b'$ and $d = d'$, then (3) becomes

$$M = \frac{2\ R\ b\ d}{z + \frac{1}{2}\ d}\left(z^2 + {}_1{}^1{}_2\ d^2\right) = R\ b\ d\ \frac{D^2 + \frac{1}{3}\ d^2}{D + d} \quad . \quad . \quad . \quad . \quad (4.)$$

Let $D =$ *an equivalent depth*, or such a depth that if the whole section of each chord were to act with a uniform resistance of R, and hence offer a total resistance of $R\ b\ d$; and if this force were concentrated at a single point, the total moment, $R\ b\ d\ D$, would be the same as the moment just found.

Then $M = R\,b\,d\,D_1 = R\,b\,d\,\frac{D^2 + \frac{1}{3}\,d^2}{D + d}$

$$\therefore D_1 = \frac{D^2 + \frac{1}{3}\,d^2}{D + d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5.)$$

Developing (5) gives

$$D_1 = D - d + \frac{4}{Z}\frac{d^2}{D} - \frac{4}{Z}\frac{d^3}{D^2} + \&c.$$

In which, if D be large compared with d, D will be but little more than $D - d$, a conclusion which is reached in an article in the *Civil Engineer's Journal*, vol. xxv. p. 234. In the article referred to, D_1 is compared with D, and the per cent. of error noted; but the per cent. of error would be less by using $D - \frac{1}{2}\,d - \frac{1}{2}\,d'$ for the depth than D. To show this numerically, let $D = n\,d$ in (5) then

$$D = \frac{n^2 + \frac{1}{3}}{n^2 + n}\,D.$$

Let $D_2 = (n-1)\,d = \left(1 - \frac{1}{n}\right) D$ = the clear distance between the chords. From these we obtain:—

Value of n.	Usual value. D.	Correct value. D_1.	Per cent. of error.	D_2.	Per cent of error between D_1 and D_2.
4	4 d	0·8166 D.	18·33	0·75 D.	8·16
6	6 d	0·8650 D.	13·50	0·83 D.	4·04
8	8 d	0·8940 D.	10·60	0·87 D.	2·69
10	10 d	0·9121 D.	8·79	0·90 D.	1·32
15	15 d	0·9388 D.	6·12	0·93 D.	0·93
20	20 d	0·9531 D.	4·69	0·95 D.	0·32

It is worthy of remark that the per centage of error is not only less in the latter than the former case, but that it errs on the side of safety, while the former does not.

When the chords are much disproportioned, *the equivalent depth* may sometimes be less than the clear depth between the chords, and sometimes greater than the distance between the centre of the chords. It is not easy to show this from the general equation (3), I shall therefore take a numerical example.

Let $b = 1$ inch, $b' = 2$ inches, $D = 26$ inches,
$d = 2$ inches, $d' = 12$ inches.

Then (1) gives $Z = 24$, $Z' = 2$; and from (3)

$$M = 37{\cdot}44\ R \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6.)$$

$$\therefore \quad D_1 = \frac{37{\cdot}44\ R}{(b\,d = 2)\ R} = 18{\cdot}72 \text{ inches.}$$

If the lower chord be used, then the maximum strain on it is

$$R' = \frac{R}{Z + \frac{1}{2}\,d}\left(Z' + \frac{1}{2}\,d'\right) = \frac{8}{25}\,R$$

$$\therefore D_1 = \frac{37{\cdot}44\ R}{(b'\,d' = 24)\ \frac{8}{25}\ R} = 4{\cdot}87 \text{ inches.}$$

which is very much less than $D - \frac{1}{2}\,d - \frac{1}{2}\,d'$.

By using *much smaller* values for b and d, the value of D_1 for the upper chord will be more than 26 inches.

The strength of the lower chord is $\frac{1}{6}\ R'\ b'\ d'^2 = 48\ R'$, in which if $R' = R$, and then compared with (6), it shows us that *one of the chords is stronger than the whole truss.* The paradox may appear more striking by supposing R' greater than R.

This seeming paradox is quite similar to the one shown in my article on triangular beams, vol. xli. p. 198 of this Journal.*

In this case the strain upon the upper chord is very much greater than upon the lower. The ratio is $\frac{R}{R'} = \frac{z + \frac{1}{2}\ d}{z' + \frac{1}{2}\ d'} = \frac{25}{8} = 3\frac{1}{8}$; so that when the fibres of the upper chord are just on the point of rupturing, those of the lower are capable of sustaining $3\frac{1}{8}$ times the strain which comes upon them.

The problem is not simply to find the greatest load which the truss will sustain, but the greatest which it will sustain without fracturing either chord. After loading it sufficiently to break the upper chord, we must in this case increase the load more than 28 per cent. to break the lower chord. By making the sections of the chords still more disproportionate, the paradox may be made more striking.

We see, then, that there may be a great waste of material by not making the chords in the proper proportion. We will now investigate the case of *an Economical Distribution of the Material in the Chords of an Open Girder.*

For this it is well known that the material should be as far removed as possible from the neutral axes, but as the chords must have depth, and as D is usually limited, we must investigate limited cases to make it practical.

If the chords are not equally liable to fracture, then some material might be removed from the one least liable, without any detriment to the whole. The first and essential condition, then, is that the extreme fibres in each chord should be equally liable to fracture. For this we must have

$$\frac{R}{z + \frac{1}{2}\ d} = \frac{R'}{z' + \frac{1}{2}\ d'} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7.)$$

But z and z' are given in terms of the sections and D; hence equation (7) will enable us to find one of the quantities when all the others are known.

If the sections are solid and rectangular, z and z' are given in equation (1).

$$\therefore \quad \frac{b'\ d'}{b\ d + b'\ d'}\ D + \frac{1}{2}\ d = \frac{b\ d}{b\ d + b'\ d'}\ D + \frac{1}{2}\ d'. \quad . \quad (8.)$$

If the sum of the areas of both sections $= A$, be given, so that

$$b\ d + b'\ d' = A. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

then (8) and (9) enable us to find two of the quantities when the other two are known.

* The strength of a square beam, when the force is applied in the direction of the diagonal, is usually given as $\frac{1}{12}\sqrt{2}\ R\ b^3$, but according to the article referred to, it should be $\frac{1}{12}\sqrt{2}\ R\ b^3 \times 1{\cdot}09125+$.

If, in addition, they are required to be of given strength, then D must be determined when two of the other quantities are given, which may be done by combining equations (3), (8), and (9).

In the last case, if A be not given, three of the quantities (b, d, b', d',) may be assumed, and the other and D may be found from (3) and (8).

A few numerical examples will illustrate the use of these equations.

Let R = R′ and $b = b'$.

Then equation (8) gives $d = d'$, in which case the areas of the two chords are equal.

Let R = 2 R′ and $d = d'$.

Then (8) gives $b\,(2\,\text{D} - d) = b'\,(\text{D} - d)$.

From which we see that $2b = b'$ when d vanishes.

1. Let $b = 1$ foot.
   Then $b\,(2\,\text{D} - 1) = b'\,(\text{D} - 1)$.
2. Let D = 6 feet.
   Then $b = \frac{5}{11}\,b'$.
   Hence $b\,d : b'\,d' :: 5 : 11$.
   But R : R′ :: 2 : 1.

From which we see that the sections are not inversely proportional to the ultimate resistances of the material in each.

Let R = R′; $d = b' = 4$ inches, $d' = 16$ inches, D = 60 inches.

Equation (8) gives $b = \dfrac{2\,d'\,\text{D} + d\,d' - d'^2}{2\,d\,\text{D} + d\,d' - d'^2}\,b = 13{\cdot}09$ inches.

Hence the section of the upper chord is $4 \times 13{\cdot}09 = 52{\cdot}36$.
" " lower " $16 \times 4 = 64{\cdot}00$.

These values in equation (3) give

$$\text{M} = \frac{\text{R}}{35}\left[52{\cdot}36\left(33^2 + 1\tfrac{1}{3}\right) + 64\left(27^2 + 21\tfrac{1}{3}\right)\right] = \left(3023{\cdot}2 +\right)\text{R}.$$

Had the upper chord retained its depth, and been 16 inches wide, thus making it of the same area as the other, we would have by the same equation

$$\text{M} = \frac{\text{R}}{38}\left[64\left(30^2 + 1\tfrac{1}{3}\right) + 64\left(30^2 + {}_1{}^1{}_2\ 256\right)\right] = 3069\ \text{R}.$$

Deduct the former . . . . . 3023 R.

Leaves a gain in strength of . . . . . 46 R.

which is a gain of $\dfrac{4600}{3023}$ per cent., or nearly $1\frac{1}{2}$ per cent.

But this requires $64 - 52{\cdot}36 = 11{\cdot}64$ square inches more material, or an increase of $\left(\dfrac{1164}{116{\cdot}36} =\right)$ 10 per cent. nearly.

EXAMPLE.

Suppose the girder is 200 feet long, and has a load throughout its whole length of 100 lbs. per inch, and $b = 4$ inches, $d' = 10$ inches, A = 40 inches, and R = R′, required d, b', and D, so as to sustain the load.

Equations (1), (3), (8), and (9) will enable us to solve it. Observe that $\text{M} = \frac{200 \times 12 \times 100}{8} = 30{,}000$.

If the laws which we assumed at the commencement of this article were true for open girders, then would the investigation which we have made be of great importance; but it is not probable that they are approximately true. When the chords are not connected by a vertical web, but are connected by ties and braces, the strain is nearly or quite uniform on all parts of the section, in which case R b d represents more nearly the actual resistance than that obtained from the expression $\frac{\text{R}}{d} y\,dy\,dx$, and R b d D more nearly the true moment than that given by equation (3).

If the strain is exactly uniform on the whole section, then will R b d $=$R$'$ b' d', or the sections will be inversely proportional to the strains, and hence for economy they should be inversely proportional to the ultimate resistances.

These remarks apply to the effective sections. All that is cut away in the chord subjected to tension, weakens it, while in the one subjected to compression, if the parts cut away be filled, or keyed, with as good material, the total section would be effective.

The general principles of the investigation are applicable to tubular girders, for the connecting parts are solid; but the moment of resistance of the vertical web must be added to the moment of the other parts for the total moment. This, however, makes D_1 still less, for the area in the immediate vicinity of the neutral axes does not resist much, but in finding the *equivalent depth* we assume that each unit resists an amount equal to R.

On account of these modifications of D_1, it should not be assumed in tubular girders, except for obtaining an approximate value of the sections.

Railway across the Pyrenees.

From the London Mechanics' Magazine, Sept., 1862.

On August 21, the first railway train drawn by locomotives crossed the chain of the Cantabrian Pyrenees, over the northern division of the Tudela and Bilbao Railway, from the seaport of Bilbao to the town of Miranda on the Ebro. The distance between these two towns is about sixty-six English miles, of which over forty are in ascending from the coast to the summit, 2163 feet above the sea, being the lowest col or pass in the whole range of the Pyrenees. The average rate of ascent from the sea is 54 feet per mile; the maximum ascent is 76 feet. The predominant curvature has a radius of only 300 yards, and the curves are continually reversing. There are two points on the line at the entrance of the Basin of Ordima, distant only 600 yards, measuring across the gorge or neck of the basin, which are fully $8\frac{1}{2}$ miles distant from each other in traveling along the line, and which

differ 456 feet in level. The time taken in the transit is 2¾ hours; and the scenery, as may be presumed from the locality, and from the frequent change of direction on the line, is magnificent and varied. The last glimpse of the northern landscape the traveler has is over the Gujuli waterfall, and down to a depth of 400 feet, to the bottom of the ravine into which it falls. The descent on the Southern side is very gradual, the fall being on an average 24 feet per mile to the level of the Ebro. The total length of the railway is 155 miles—the length of the portion we have described being 66 miles, and the cost of these 66 miles more than £1,000,000 sterling. The cost of the whole line, stations, rolling stock, &c., was £250,000,000, all the capital being Spanish money, chiefly subscribed in Bilbao and its commercial connexions. Not a share is held out of Spain or its colonies. A model of the passage of this railway across the Pyrenees is to be seen in the Engineering Court of the International Exhibition.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

On the Giffard Injector. By John W. Nystrom.

The Giffard Injector is now gaining very rapidly its proper position for feeding steam boilers, and as its operation is yet a mystery to many, it is thought that an article on its theory will not be out of place in the *Journal.*

The apparatus is yet a philosophical curiosity. Engineers have called it a "*scientific toy,*" and predict its proper destination to be "*in the show-window of a philosophical instrument maker,*" proving how ready we are to condemn what we do not understand.

William Sellers & Co., of this city, are now manufacturing the Giffard injector, and are the sole agents. They have sold about 1200 injectors of different sizes for locomotive, stationary, agricultural, and marine boilers.

Its application does away entirely with the necessity of pumps for feeding boilers, and the various movements for working them in all classes of engines, and, in fact, wherever a boiler is used and steam produced; it is an adjunct to the boiler, and entirely independent of the engine, and is put in operation by simply opening connexions with the boiler; and having no parts in motion, it is not liable to wear, nor otherwise to get out of order.

The size of this apparatus is comparatively small, and its application is rendered especially easy by the fact that it can be placed in any position, vertical, horizontal, or otherwise, near to, or at a distance from the boiler, and at any reasonable height above the level of the feed water.

The apparatus is connected with the boiler by two pipes, one leading from the steam space, and the other conducted to the lowest convenient point of the water space; it will operate with steam at any usual pressure, and it will supply itself from the hot-well of a condensing engine.

Fig. 1.

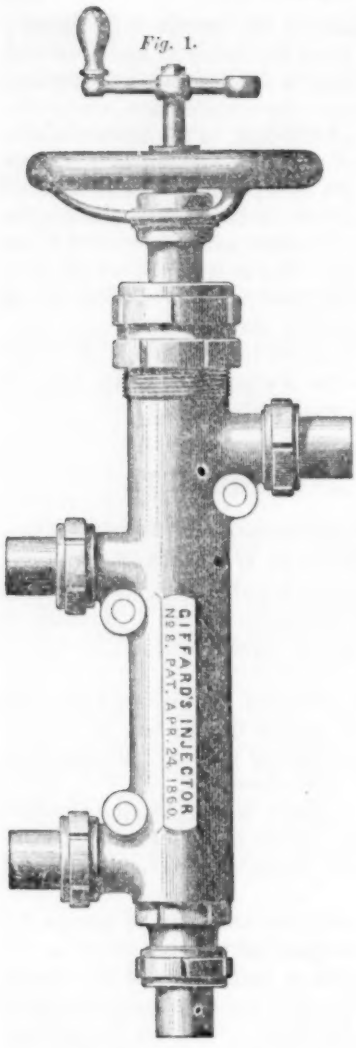
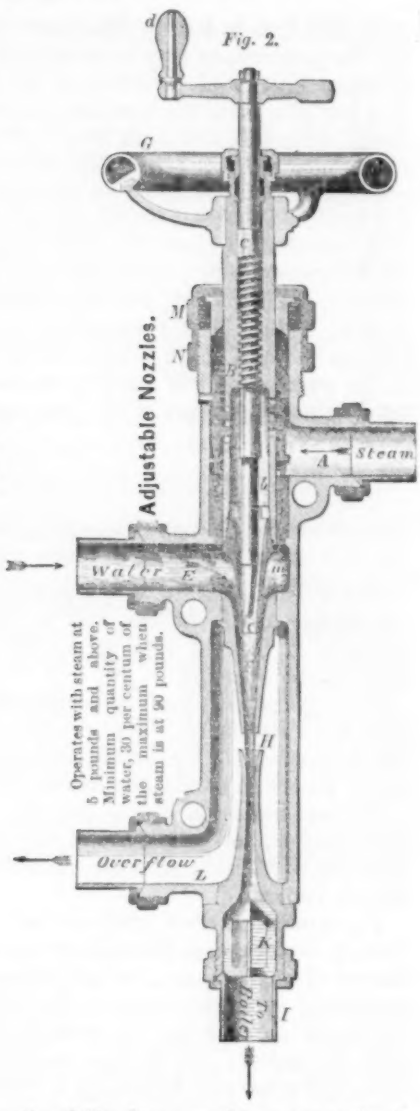


Fig. 2.



Referring to the illustration, the following are the parts to be described:—

A. Steam pipe leading from the boiler.

B. A perforated tube or cylinder, through which the steam passes into the space *b*.

C. Screwed rod for regulating the passage of steam through the annular conical space *c*, and worked by the handle *d*.

E. Suction pipe, leading from the tank or hot-well to small chamber *m*.

F. Annular conical opening or discharge pipe, the size of which is regulated by the movement of the tube or cylinder B.

G. Hand-wheel for actuating the cylinder B.

H. Opening, in connexion with the atmosphere, intervening between discharge pipe F and the receiving pipe through which the water is forced.

I. Tube through which the water passes to the boiler.

K. Valve for preventing the return of the water from the boiler when the injector is not working.

L. Waste or overflow pipe.

M. Nut to tighten the packing ring *g* and upper packing *i* in cylinder B.

N. Lock nut to hold M.

There are two kinds of injectors made, namely, with *adjustable* and with *fixed nozzles*. The one with fixed nozzles (fig. 3) has not so much range of delivery as the adjustable one, and I would suggest two injectors for marine boilers; one with fixed nozzle, calculated for the net supply of feed, and one of smaller size, with adjustable nozzle, by which to regulate the feed.

Fig. 3.

WM SELLERS & Co
PHILADA. N° 0000
Operates with steam at 40 pounds and above. Minimum quantity of water, 70 per centum of the maximum when steam is at 90 pounds.

The fixed nozzle injector is considerably cheaper, as will be seen in the price table.

After having examined the injector and its operation, it appears somewhat curious that steam is able to force water into itself; but since we know that the injector does work, we are convinced that there are physical laws brought into action which require further investigation.

As the steam drives the water into the boiler, it is evident that it is not the pressure of that steam, but its dynamic momentum that performs the operation. The dynamic momentum in this case is the weight of steam passed through in a unit of time multiplied by its velocity, which must be equal to the dynamic momentum of the water and steam after contact, or the weight of the mixed water and steam multiplied by its velocity, and this last momentum must be great enough to overcome the pressure in the steam boiler.

Letters denote

M = weight of steam in pounds which passes through the injector per hour.

V = velocity in feet per second of the steam.

m = weight of water in pounds forced through the injector per hour.

v = velocity of the mixed water and steam.

As the steam takes the water from a stationary position, the case will be the same as figure and formula 193, p. 157 Nystrom's Pocket Book, namely, one mass in motion striking one at rest.

Steam momentum $\text{M V} = v\,(\text{M} + m)$ water steam momentum,

and
$$v = \frac{\text{M V}}{\text{M} + m} \quad . \quad . \quad . \quad (1.)$$

In this formula we have given from the performance of the instrument the quantity of the water m, and the temperature of the injection water, which give us the quantity of steam M, and there remains to find the velocity V of the steam.

Letters denote

P = pressure of steam in pounds per square inch in the boiler, including the atmosphere.
S = specific gravity of the steam compared with water.
g = 32·166 force of gravity.
h = height in feet of a column of steam of uniform density that will balance its own pressure.

$$h = \frac{144\ \text{P}}{62{\cdot}5\ \text{S}} = \frac{2{\cdot}3\ \text{P}}{\text{S}}.$$

The final velocity due to this column of steam will be the same as the velocity of the steam from the boiler passing into a vacuum. Formula 1, page 195, Nystrom's Pocket Book.

$$\text{V} = \sqrt{2gh} = 8{\cdot}02\ \sqrt{\frac{2{\cdot}3\ \text{P}}{\text{S}}}.$$

$$\text{V} = 12{\cdot}166\ \sqrt{\frac{\text{P}}{\text{S}}}. \quad . \quad . \quad . \quad (2.)$$

In most steam tables we have the specific gravity of steam compared with air, which multiplied by 0·00129363, the specific gravity of air, will give the true value of S in formula 2.

EXAMPLE.—A steam pressure of P = 75 pounds per square inch, S = 1·991 × 0·001296 = 0·002580336. See Nystrom's Pocket Book, page 249.

Required the velocity (V = ?) of the steam passing into vacuum?

$$\text{V} = 12{\cdot}166\ \sqrt{\frac{75}{0{\cdot}00258}} = 2073 \text{ feet per second.}$$

For the mixture of water and steam in the injector, letters denote:
Q = cubic feet of steam per hour of temperature T, and volume coefficient k, required to operate the injector.
q = cubic feet of feed water of temperature t to supply the injection per hour.
t' = temperature of the delivery.
We shall have

$$\frac{\text{Q}}{k}(990° + \text{T}) + q\,t = t'\left(\frac{\text{Q}}{k} + q\right)$$

and
$$\text{Q} = \frac{q\,k\,(t' - t)}{990° + \text{T} - t'} \quad . \quad . \quad (3.)$$

From William Sellers & Co.'s experiments with different injectors

and under different circumstances, we have the following data of a No. 8 injector:

P = 75 lbs., T = 311°, $k = 383$, $q = 161{\cdot}6$, $t = 42°$, $t' = 134°$, which inserted in formula 3 will give the quantity of steam,

$$Q = \frac{161{\cdot}6 \times 383\,(134° - 42°)}{990° + 311° - 134°} = 4879{\cdot}3 \text{ cubic feet.}$$

The weight of this steam will be

$$M = 4879{\cdot}3 \times 0{\cdot}00258 \times 62{\cdot}5 = 1224 \text{ pounds.}$$

The weight of the injection water will be

$$m = 161{\cdot}6 \times 62{\cdot}5 = 10100 \text{ pounds.}$$

Now we have all the values given for formula 1, namely, M = 1224 lbs., $m = 10100$ lbs., and V = 2073 feet per second, when the velocity of the steam and water will be

$$v = \frac{1224 \times 2073}{1224 + 10100} = 224 \text{ feet per second.}$$

The column corresponding to this velocity will be (see formula 2, p. 195, Nystrom's Pocket Book)

$$h = \frac{V^2}{2g} = \frac{224^2}{64{\cdot}33} = 780 \text{ feet.}$$

A column of water pressing 75 lbs. per square inch will be

$$h = \frac{144 \times 75}{62{\cdot}5} = 173 \text{ feet.}$$

From which the force of injection will be $\frac{780}{173} = 4\frac{1}{2}$ times the resistance of the steam in the boiler.

I do not mean to say that this force ($4\frac{1}{2}$ times) is fully realized, as the foam form of the mixed steam and water diminishes the effect considerably, but it has been proved by experiments that an injector can feed a boiler with 50 per cent. more pressure than that working the instrument.

For feeding steam boilers, the injector is theoretically perfect; all the heat in the steam working the apparatus is returned to the boiler, except what is lost by radiation; but for elevating water or for fire-engines, the injector will not be so economical, as I shall here endeavor to show.

The natural effect required for pumping 161·6 cubic feet of water into a boiler with 75 lbs. pressure will be

$$H = \frac{144\,q\,P}{33000 \times 60} = \frac{144 \times 161{\cdot}6 \times 60}{33000 \times 60} = 0{\cdot}705 \text{ horses.}$$

The natural effect of 4879·3 cubic feet of steam of 75 lbs. per hour will be

$$H = \frac{144\,Q\,P}{33000 \times 60} = \frac{144 \times 4879{\cdot}3 \times 60}{33000 \times 60} = 21{\cdot}3 \text{ horses.}$$

Or the effect of the steam is 30 times the effect it accomplished in the

injector. In these formulas the atmospheric pressure is subtracted from the 75 lbs., leaving P = 60 lbs.

Capability of the Injector.—The capability of the injector depends on its size, pressure of steam, and the temperature of the supply water. From the performance of the injector, it is evident that a perfect vacuum is necessary at the point where the steam and water meets, for if the supply water is very hot and the steam is high, the injector may not work at all. The temperature of the delivery should be much below 212° Fahr. The following formula will show the maximum temperature t of the supply water for a given temperature of steam T under which the instrument will operate:

$$t = 222 - \tfrac{1}{3}\,\mathrm{T}. \qquad . \qquad . \qquad . \qquad (4.)$$

EXAMPLE.—Required the maximum temperature (t = ?) of feed water that will work in the injector under a steam pressure of P = 65 lbs. per square inch T = 301°.

$$t = 222 - \tfrac{1}{3}\,301 = 122°\text{ the answer.}$$

The capability of the injector will be found by the following formula, in cubic feet of feed water delivered per hour:

$$q = \frac{12{\cdot}6\ \mathrm{N}^2}{t}\sqrt{\mathrm{P}}. \qquad . \qquad . \qquad . \qquad (5.)$$

In which N = number or size of the injector, being the diameter of the receiving throat in centimetres, which multiplied by 0·63 gives it in 16ths of an inch.

EXAMPLE.—Required the capability of an injector of the size No. 6, to be worked with a steam pressure of P = 105 lbs. per square inch, the temperature of the supply water being $t = 45°$?

$$q = \frac{12{\cdot}6 \times 6^2}{45}\sqrt{105} = 104\text{ cubic feet per hour.}$$

To find what size injector is required for a given steam engine.

Letters denote

A = area of the cylinder piston in square inches.
S = stroke of piston in feet under which steam is fully admitted.
n = double strokes or revolutions per minute of the engine.
k = volume co-efficient of the steam in the boiler. (See p. 249 Nystrom's Pocket Book.)
q = net quantity of water in cubic feet per hour required for feeding the boiler.

$$q = \frac{\mathrm{A\ S}\ n}{k}. \qquad . \qquad . \qquad . \qquad (6.)$$

TABLE OF CAPACITIES OF DIFFERENT SIZE INJECTORS, FURNISHED BY WILLIAM SELLERS & CO.

SIZE.	CASH PRICES.			PRESSURE OF STEAM IN POUNDS.														
	ADJUSTABLE NOZZLES.		FIXED NOZZLES.	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
	Brass Bodies Polished.	Iron Bodies.	Iron Bodies	CUBIC FEET OF WATER DISCHARGED PER HOUR.														
No. 2.	$ 50	$ 40	$ 30	5·050	6·304	7·344	8·254	9·073	9·824	10·522	11·436	11·794	12·381	12·941	13·479	13·996	14·493	14·941
3.	$ 60	$ 50	$ 40	11·465	14·300	16·658	18·723	20·581	22·284	23·867	25·357	26·752	28·084	29·355	30·574	31·746	32·876	33·890
4.	$ 80	$ 65	$ 50	20·500	25·568	29·786	33·476	36·799	39·845	42·674	45·328	47·834	50·215	52·488	54·667	56·762	58·783	60·596
5.	$100	$ 85	$ 65	32·175	40·129	46·748	52·553	57·754	62·536	66·977	71·140	75·074	78·811	82·379	85·799	89·088	92·259	95·106
6.	$125	$105	$ 85	46·500	57·997	67·564	75·935	83·471	90·381	96·799	102·820	108·500	113·900	119·060	124·000	128·760	133·340	137·450
7.	$150	$125	$105	50·431	79·184	92·246	103·670	113·960	123·400	132·160	146·380	148·140	155·520	162·550	169·300	175·790	82·050	187·670
8.	$175	$150	$125	83·145	103·700	120·800	135·780	149·250	161·600	173·080	183·840	194·000	203·660	212·880	221·720	230·220	238·420	245·770
10.	$225	$185	$150	130·500	162·750	189·600	213·100	234·250	253·440	271·450	288·530	304·490	319·640	334·110	347·990	361·320	374·180	385·730
12.	$275	$220	$180	188·600	235·230	274·030	307·980	338·540	366·570	392·600	417·010	440·070	461·970	482·890	502·930	522·210	540·800	557·490
14.	$325	$260	$210	257·500	321·150	374·130	420·490	462·230	500·490	536·020	569·350	600·830	630·740	659·290	686·660	712·980	738·360	761·140
16.	$375	$300	$250	337·220	420·590	489·970	550·680	605·340	655·440	701·980	745·630	786·850	826·020	86·420	899·260	933·730	966·970	996·800
18.	$425	$345	$290	427·800	533·560	621·590	698·600	767·940	831·500	890·540	945·910	998·210	1047 900	1095·400	1140·800	1184·500	1226·700	1264·600
20.	$475	$390	$330	529·150	659·600	768·830	864·090	949·840	1028·100	1101·500	1170 000	1234·700	1296·100	1354·800	1411·100	1465·100	1517·300	1564·100

One nominal horse power per hour will require one cubic foot of water per hour. When the pounds of coal consumed per hour can be ascertained, divide this by 7·5, and the remainder will be the quantity of water in cubic feet per hour.

EXAMPLE.—What size injector is required for a steam engine 36 inches diameter, A = 1017·8 square inches area of piston, stroke of piston S = 4 feet, making $n = 52$ revolutions per minute, with 60 lbs. steam, $k = 383$? The required quantity of water will be

$$\text{Formula 6, } q = \frac{1017{\cdot}8 \times 4 \times 52}{383} = 552 \text{ cubic feet per hour.}$$

In the preceding table we find under 60 lbs. 655 corresponds with No. 16, the nearest size injector required.

Should the temperature of the feed water be very high, the size of the injector should be calculated from this formula:

$$N = \sqrt{\frac{A\,S\,n\,t}{12{\cdot}6\,\sqrt{P}}}. \quad . \quad . \quad . \quad (7)$$

The temperature of the delivery will be found in the following formula:

$$t' = \frac{990 + T + m\,t}{m+1}. \quad . \quad . \quad (8)$$

$$m = \frac{30(180 - t)}{T}. \quad . \quad . \quad . \quad (9)$$

In which m = weight of the water compared with that of the steam which passes through the injector in a unit of time.

EXAMPLE.—An injector is to be worked with a steam pressure of P = 95 lbs. per square inch, T = 328°. The temperature of the supply-water is $t = 45°$. Required the temperature ($t' = ?$) of the delivery?

$$m = \frac{30\,(180 - 45)}{328} = 12{\cdot}35.$$

The weight of water will be 12·35 times that of the steam in the delivery, and

$$t' = \frac{990 + 328 + 12{\cdot}35 \times 45}{12{\cdot}35 + 1} = 140°,$$

the required temperature of the delivery.

Directions for operating the Injector.—All the pipes leading to or from the injector must be of the same diameter as that where it is connected with the apparatus. All the pipes should be supplied with cocks, by which to regulate the operation, so as to handle the instrument as little as possible. The steam-pipe should be taken from the highest part of the boiler, so as to avoid priming, which prevents the efficient working of the injector. The delivery-pipe should be as short and straight as possible, to reduce friction. The injector should not be attached to the steam-pipe leading to an engine, unless the pipe be unusually large; the variation in pressure will break up the jet. It is very important that the water supply-pipe should be short and straight where the water does not gravitate to the injector; for this reason this pipe should be carried vertically down as far as the water-level in the

supply-cistern, which must not be more than five feet below the water chamber in the injector. In locating the instrument, place it as low as possible, as the injector is started more easily under a head. In attaching the injector to small boilers generating a great quantity of steam, care must be taken to prevent the oscillation in the steam pressure from being suddenly communicated to the injector, as this will break up the jet; for this reason the opening of the injector-pipe on locomotives should not be close to that leading to the cylinder; starting the engine will make the injector cease working if this difficulty is not guarded against. A good preventive in such cases is to admit the steam to the injector through numerous small openings, in place of one large one.

When the apparatus is to be started, turn the wheel so as to admit a small quantity of water, then open the steam-cock, turn slightly the handle, which will admit a small quantity of steam; and a partial vacuum is thus produced, causing the water to enter through the supply-pipe. When it is observed at the overflow-pipe that the injector takes the water, the supply of steam or water may be increased as required, up to the full capacity of the instrument.

The jamming down of the handles *d* and G should be avoided; the instrument is made neither steam nor water-tight, and when stopped, the steam and water must be shut off by the cocks in the pipes.

Oil of Asphaltum for the Preservation of Boilers.

M. Dollfus reports to the *Societé Industrielle* of Mulhouse his success in using the heavy oil extracted by M. Lebel from the asphaltum and bitumen at Pechelbronn. He says that it is perfectly successful and very economical as an unguent for heavy machinery. He applied it to the inner surface of his boilers and heaters by warming them so as to make the oil more fluid, and then applying it in a thin coat by means of a common broom. The results were very satisfactory; the calcareous crusts were gradually detached and the metal every where exposed. "I continue to use the oil whenever I clean a boiler, and I judge that the expense, which is about 10 kilos. (20 lbs.) for a boiler of 45 horse-power, is largely compensated by the economy of fuel in consequence of the metal being clean: repairs are also much less frequent, as the boilers do not burn out so freely."—*Bulletin de la Societé Industrielle de Mulhouse.*

Paraffin Oils.

From the London Intellectual Observer, July, 1862.

At the request of the Manchester Sanitary Association, Mr. Charles O'Neil, F. C. S., has examined many specimens of paraffin oils. Out of twenty-five bought in Manchester, sixteen agreed with the genuine samples of the Paraffin Company; the other nine differed from these, and from each other; three or four purported to be American, and

were called petroline, kerosine, and photogene. He also obtained fourteen samples from the springs in Pennsylvania and Canada. One sample from London and one from Liverpool formed an explosive vapor with air at as low a temperature as 60° Fahr., and might be considered as decidedly unsafe. At 85° there gave an explosive mixture with air. Of the remainder, only four formed an explosive mixture at 100°. Of the rest three did the same at 120°, and the twenty that were left did so at 150°. Of the twenty that would not make an explosive mixture at 120°, two were American, and eighteen Young's, all of whose manufacture were found safe. Out of thirty-two samples, twenty were quite safe, three less so, and nine dangerous. In specific gravity, the American oils are generally below 816°, but two bad samples were as high as 865°. Thus specific gravity is no test of their safety. Nor is the boiling point, as many substances have so high a diffusive power as to compensate for high boiling points—coal naphtha, for example, which boils at 260°, gives an explosive mixture almost instantly even at the freezing point.

Action of Mordants in Dyeing, and the presence of Titanium in good Iron.

From the London Intellectual Observer, July, 1862.

On May 29th, several interesting papers were read. An elaborate memoir by Mr. W. Crum, "On the action of Mordants in Dyeing," explained, with much detail, the nature of the union between fabrics and dyeing materials. Mr. Crum repudiated the idea that any chemical union took place, but regarded the action in some cases as one of adhesion to an extended surface, in others where the coloring matter (or mordant and coloring matter) is in solution, absorption took place. The structure of the fibre bears out this view, for on examining cotton under the microscope it is seen to be composed of flattened tubes with translucent walls, permeable, no doubt, to fluids. When mordants are used they are often deposited within the fibre, and retained there mechanically, and afterwards, combining with the dye, serve to fix it in the material. What is technically termed *dead cotton* does not take the dye, for being immature or imperfectly formed fibre, it possesses no central tube; it occurs in small quantities along with ordinary cotton, and remains white and unaffected after mordanting and dyeing. Mr. Crum exhibited numerous specimens of dyed and printed cotton fabrics in which threads and bundles of undyed dead fibres were very well seen.

On the same evening, Mr. Riley read a paper in which he announced the presence of titanic acid in a number of specimens of clay which he had tested for that substance; he believed that it was an invariable constituent of clay. He found also, that in all cases in which the blast furnaces produced good iron, titanium was present. This result is in accordance with the conclusions of several chemists and manufacturers, who have pursued experiments in the same direction.

Proceedings Chem. Soc., May 29, 1862.

On the Constitution of Sea-Water, at different Depths, and in different Latitudes. By George Forchhammer, Ph. D., Professor of Mineralogy in the University of Copenhagen.

Proc Royal Society, May 22, 1862.

Professor Forchhammer was present at the meeting, and, by request of the President, gave a statement of the principal results of his researches. He first, however, took occasion to express his great satisfaction in being allowed the opportunity of personally and gratefully acknowledging the liberality with which men of science in this country had entered into his views and supplied him with specimens requisite for carrying on his inquiries; and he particularly mentioned the name of a late distinguished Fellow of this Society, Sir James Clark Ross, who had kindly furnished various samples of sea-water procured in his Antarctic voyage.

The number of elements hitherto found in sea-water the author stated to be thirty-one, viz: Oxygen, Hydrogen, Azote in ammonia, Carbon in carbonic acid, Chlorine, Bromine, Iodine in fuci, Fluorine in combination with calcium, Sulphur as sulphuric acid, Phosphorus as phosphoric acid, Silicium as silica, Boron as boracic acid, discovered by the author both in sea-water and in sea-weeds, Silver in the Pocillopora alcicornis, Copper very frequent both in animals and plants of the sea, Lead very frequent in marine organisms, Zinc principally in sea-plants, Cobalt and Nickel in sea-plants, Iron, Manganese, Aluminium, Magnesium, Calcium, Strontium and Barium, the latter two as sulphates in fucoid plants, Sodium, Potassium. These twenty-seven elements the author himself had ascertained to occur in sea-water; the presence of the next four elements, viz: Lithium, Cæsium, Rubidium, and Arsenic, has been shown by other chemists.

Of these elements only a few occur in such quantity that their determination has any notable influence on the quantitative analysis of sea-water, viz: Chlorine, Sulphuric acid, Magnesia, Lime, Potash, and Soda. The others, as far as their existence has been determined in the sea-water itself, are found in the residue which remains after evaporation to dryness and redissolution of the salts in water.

The author next stated that in the water of the ocean far from the shores the principal ingredients always occur very nearly in the same proportions. If we assume chlorine=100, the mean proportion of the other leading constituents is as follows:—

	Mean proportion.	Maximum.	Minimum.
Sulphuric acid, .	11·89	12·09	11·65
Lime, . .	2.96	3·16	2·87
Magnesia, .	11·07	11·28	10·95
All salts, . .	181·10	181·40	180·60

These proportions apply only to specimens obtained at a long distance from shores, or in the open ocean. In the interior of the Baltic, for instance, the proportion of chlorine to sulphuric acid is as 100 to 14·97—to lime as 100 to 7·48; and the proportion of chlorine to all salts as 100 to 223·0. This constant proportion of the different con-

stituents in the ocean depends evidently not upon any chemical combination and affinity between the different substances, but upon the enormous quantity of salts in the whole ocean, which renders imperceptible any difference that might otherwise arise from the different proportion in which salts are carried into the sea by rivers. It depends besides, on the uniform action of the numberless organic beings inhabiting the ocean which abstract sulphuric acid, lime, potash, and magnesia from the water, and render them insoluble.

The mean quantity of solid matter in the water of the ocean generally, the author found to be 34·304 per 1000. To determine this mean quantity he has divided the ocean into regions, viz :—

1st Region. Atlantic, from the Equator to 30° N. lat.; mean 36·169.

2d Region. Atlantic, from 30° N. lat. to a line from the north of Scotland to the north of Newfoundland; mean 35·976.

3d Region. From the northern boundary of region 2 to the south coast of Greenland; mean 35·556.

4th Region. Davis's Strait and Baffin's Bay; mean 33·167.

5th Region. Atlantic, between 0 and 30° S. lat.; mean 36·472.

6th Region. Atlantic, between 30° S. lat. and a line from the southernmost point of Africa to the southernmost point of America; mean 35·038.

7th Region. Between Africa and the East Indian Islands; mean 33·868.

8th Region. Between the East Indian and the Aleutic Islands; mean 33·506.

9th Region. Between the Aleutic and the Society Islands; mean 35·219.

10th Region. The Patagonian stream of cold water; mean 33·966.

11th. The Antarctic region; mean 28·563.

Besides these regions of the great ocean, the author enumerates some other regions, which are under the decided influence of the surrounding land. Such are the North Sea, with a mean quantity of solid matter of 32·806 per 1000; the Kattegat and Sound, with a mean of 15·126; the Baltic, mean 4·807; the Mediterranean, mean about 37·5; the Black Sea, mean 15·894. Of the proportion in the large bays of America the author had only one observation, viz: in water from the Caribbean Sea, in which the quantity of saline matter was found to be 36·104 per 1000.

The author then showed that the equatorial regions contain the greatest percentage of saline matter, and that this peculiarity is owing to the evaporation under and in the neighborhood of the line being greater than the quantity of water supplied by the rain falling on the sea and by the rivers flowing from the land; that the equilibrium is maintained by polar currents, which bring water with less saline matter to the equatorial regions. The mean quantity of saline ingredients in the equatorial regions of the ocean is about 36·2 per 1000, while in the polar regions it is about 33·5.

The North Atlantic Ocean contains much more salt than the South

Atlantic, which the author explains by the prevailing influence of the Gulf-stream: and from his analyses of many samples of water taken in the current which flows from N. E. to S. W., between Iceland and the east coast of Greenland, he thinks it highly probable that this East Greenland current is in reality not a polar current, but a returning branch of the Gulf-stream, its mean quantity of salt being nearly the same as in the northern part of the Atlantic Ocean, viz: 35·5 per 1000.

The author then compared the Mediterranean with the Baltic, and stated that there is a double current at the entrance of the Baltic as well as in the Straits of Gibraltar; but with this difference, that the under-current of the Mediterranean runs out of, and the surface-current generally runs into, that sea; whereas the under-current of the Baltic is an entering one, and the surface-current of the Sound generally runs out into the Kattegat and North Sea. He showed, moreover, that the deep water in both seas is richer in salt than that from the surface, and consequently has a greater specific gravity.

In the Atlantic he found the reverse, viz: that the quantity of saline ingredients in the water *decreases* with the depth, if the samples are taken at some distance from the shore; and as his analyses are sufficiently numerous, and include specimens from great depths (12,000 feet), he considers this unexpected result to be tolerably well established. He thinks that this fact would prove the existence of a polar current in the depths of the Atlantic, as well as in some parts of its surface.

In the sea to the east of Africa he found the quantity of saline matter slightly increasing with the depth.

Gigantic Masses of Rolled and Forged Iron.

From the Intellectual Observer, June, 1862.

Among the stupendous masses of iron exhibited* may be mentioned the forged double crank shaft weighing twenty-five tons, and designed for the engines of one of the new armor-plated vessels now building. Forged armor-plates are also shown more than six feet in width, that can be manufactured of any thickness and almost of any length required, and a rolled boiler plate 112 square feet is exhibited.

*At the International Exhibition.

The Exportation of Iron from Great Britain.

From the Mechanic's Magazine, August, 1862.

The exportation of iron in its various forms experienced some reduction last year, the total value of the iron and steel sent abroad having been £10,341,574, against £12,154,997 in 1860. There was an increase in pig from £974,065 to £1,047,318; but bar, bolt, and rod iron declined from £2,385,871 to £1,885,605; railroad iron from £3,408,759 to £2,903,357; cast iron, from £832,638; wire, from £250,087 to £207,317; wrought iron of all kinds, from £3,317,349 to £2,868,923; and unwrought steel, from £986,228 to £727,840. It was in 1853 that the export iron trade assumed its present large

proportions, having increased in that year to £10,845,422 as compared with £6,684,276 in 1852, £5,830,370 in 1851, &c. The value of the machinery exported last year was never exceeded in any previous twelve months, steam engines having figured for £1,243,467, and other kinds of mechanical apparatus for £2,976,221; while in 1860 the totals were £1,238,333 and £2,599,488 respectively. In 1850 the value of the steam engines exported was only £423,977, and of the general machinery £618,189; so that during the last ten or eleven years a vast development has taken place in the demand for British machinery in foreign countries and in the colonies.

An Improved Mode of and Apparatus for Transmitting Despatches and Small Articles, by the agency of Electricity. Patented by HENRY COOK, of Manchester.—Dated 8th January, 1862.

From Newton's London Journal of Arts, September, 1862.

This invention relates to a novel method of transmitting written or printed despatches, letters, or other small articles, by electricity. The telegram, despatch, or information to be transmitted, is written or printed on paper, placed in a carriage, which runs along a line of railway, laid in a tube or pipe formed of a series of hollow electric coils or electro-magnets. The carriage is propelled by the agency of magnetic electricity, which is induced in the hollow coils by a traveling battery mounted on the carriage. It is well known that a bobbin, surrounded with coils of insulated iron or copper wire, has the power, when the above-mentioned wire has a current of electricity passed through it, of attracting into its interior a bar of iron of the length of the bobbin. Upon this principle the electric propeller for transporting despatches, letters, and other small articles, is constructed.

On the Chemistry of Digestion. By DR. MARCET.

From the Lond. Chemical News, No. 134.

Until very recently but little attention had been bestowed by chemists on those changes which go on under the influence of organic life, and, in consequence, many vague speculations had been entertained and published concerning this most interesting department of science; of late years, however, many able investigators had taken the subject in hand, and much progress had already been made. Many obstacles attended these inquiries on account of the difficulty of observing the conditions of the immediate principles during life; the term "immediate principles" being applied to those substances produced by organic life from which no less complex body could be obtained without a complete destruction of the substance in question. As an example of the power possessed by organic substances of preventing ordinary chemical reactions, the influence of albumen or the serum of blood on lactate of iron was shown. A mixture of this salt with white of egg gave no color with ferrocyanide of potassium, although the lactate itself furnished the ordinary blue precipitate. With respect more es-

pecially to the chemistry of digestion, it appeared that after a long fast the contents of the stomach were alkaline, and very small in quantity; as soon, however, as food was introduced, the gastric juice was secreted in quantity, and an acid reaction was perceptible. The object of the action of the gastric juice was, no doubt, to render the food capable of absorption; and accordingly it was found that albuminous, gelatinous, and other similar matters introduced into the stomach, became converted into a substance called "peptone," which, according to Lehmann, might be viewed as the same body, whatever nitrogenous food was employed; it had been shown, however, that the peptones resulting from the digestion of cartilage and the mucous membranes rotated the plane of polarization of light, whereas peptones from albumen had not this power. The gastric juice, which was at first abundant, gradually diminished in quantity and became more acid, probably in order that it might act on the less masticated or less easily digestible portions of the food. Besides the conversion of the albuminous matter into peptone, another important change took place in the stomach, namely, the decomposition of the neutral fats and setting free of the fatty acids; this was an important decomposition, for the bile would form an emulsion with a fatty acid, but not with a neutral fat; some of the fat sometimes escaped decomposition, but the pancreatic secretion formed an emulsion with this portion. The formation of an emulsion seemed to depend on the incrustation of each globule with a layer of soap, which prevented the globules from coalescing, and increased their specific gravity, so that they remained for a long time suspended in the liquid. Dr. Marcet considered that in experiments on digestion it was always better to employ gastric juice obtained directly from the stomach of an animal, instead of an artificial compound, such as was employed by some physiologists. There was some dispute as to the nature of the free acid existing in the gastric juice, —some supposed it consisted of hydrochloric acid, while others imagined that other free acids, especially lactic acids, were present; since quantitative determinations of the amount of hydrochloric acid and of the bases present in the gastric juice showed that there was more hydrochloric acid than was sufficient to combine with all the base, it was evident that there must be some free hydrochloric acid present; it was highly probable, however, that other acids were present in a free state, for on placing some gastric juice in a dialyzer and leaving it until all the hydrochloric acid had passed away, the remaining matter was found to be still acid. It had been supposed that the soda introduced in the shape of common salt with the hydrochloric acid of the gastric juice, was employed in the formation of bile; but it appeared from the interesting researches of Dr. Bence Jones that this was not exactly the case, for healthy blood was always alkaline, but appeared to have an incessant tendency to become acid; the acid was, however, as rapidly removed by the secreting organs; and it had been found that when the secretion of gastric juice was active the urine became less acid, and it gradually increased in acidity as the gastric secretion was moderated, so that the two actions balanced one another.

It appeared that if no salt were supplied with the food eaten, the hydrochloric acid secreted was totally absorbed again with the food, furnishing an example of that wonderful power of adaptation to circumstances which enabled animal life to continue under varying external conditions. The only materials of the food that passed through the stomach and intestines undigested were such substances as hair, horns, &c.; together with these, however, a small quantity of excrementitious matter, obtained from the various secretions poured into the intestines, was always present, and a crystalline matter of definite chemical composition, and bearing some analogy to cholesterine, might be extracted from it.

Lecture before the Royal Institution of Great Britain, on Coal.

By WARRINGTON W. SMYTH, Esq., F. R. S.

From Newton's London Journal, September, 1862.

The speaker commenced by proposing to select one portion only of a very large subject; and, neglecting chemical and statistical and mining particulars with reference to this important mineral, to confine himself to the physical conditions under which it is found to occur. The enormous value of the coal of this country might be understood from the simple facts that nearly 300,000 of our fellow-subjects find their employment in the coal-mines: and that the total quantity raised in 1860 amounted to no less than eighty-four millions of tons.

Mr. Smyth then proceeded to describe the nature of the various substances with which the coal is associated, referring to specimens on the table from the field of South Yorkshire. Comparison was made between the total thickness of carboniferous rocks or coal measures of different districts, as well as between the total thickness of coal (in the aggregate of the seams); and hence, it was shown, we have one reason for not estimating the value of a coal-field merely by its area, as we find it laid down in a geological map. Thus, the well-known Durham field, with a thickness of measures of about 2000 feet, has a total thickness of coal of 50 feet. The Derbyshire, 2000, and almost twice the thickness of coal; the North Staffordshire, 6000 feet of measures, and 130 of coal; whilst the South Welsh and Saarbrücken fields exhibit thicknesses of 12,000 to 15,000 feet, with a proportionate increase) especially in the latter) of coal.

A second reason for mistrusting area as a criterion of the importance of a coal district, is the various forms into which the coal measures have been thrown or moulded by agencies operating at a later date in the earth's crust, whence some districts may exhibit by outcrops an indication of the full amount of their entire contents, whilst in others the beds pass with a gradual inclination beneath newer formations, through which they may nevertheless be accessible. As instances of this were quoted the vast accession of mineral wealth added, even in the last twelve years, to the Westphalian coal-field, by the explorations carried out through the covering of cretaceous rocks which clothe the northern side of the coal-field, and the remarkable

pit lately completed by the Duke of Newcastle, at Shireoak, which commenced at a distance of several miles from any visible coal-measures, pierced the new red sandstone and magnesian limestone, and reached the "top-hard" coal at 515 yards in depth.

Mr. Smyth then described certain physical features produced in the coal seams subsequently to their consolidation, such as the *cleat* and *backs*, or various nearly vertical divisions, often more or less filled with carbonate of lime or iron pyrites, which add greatly to the amount of ash and clinker.

In referring afterwards to the principal families of plants which are found either in, or associated with, the coal, he wished to show that their occurrence throws a light on the origin of the coal seams, which again becomes an important guide in enabling us to judge of the continuity of various fields,—a question fraught with vital importance, in consequence of the rapid rate at which some of them are being exhausted. Thus the position of the stigmaria in the under-clay or floor of the seam, and of the stems of *Sigillaria*, *Lepidodendron*, *Calamites*, &c., in the roof strata, point to the probability of the growth of the vegetable matter *in situ*. The existence of numerous upright stems, and especially those occurring so often and so dangerously to the miners in the roof of certain coals, is a strong confirmation of the gradual depression of the tract in which these plants grew; and Göppert has shown that the careful examination of a number of seams proves the existence in the coal itself of every family of plant which has been met with in the coal measures.

Thus much had referred to the true carboniferous period, in which it is commonly supposed that a vigorous vegetation first arose, but the speaker described his finding, a few months since, in the Laxey lead and copper mine, in the Isle of Man, at 120 fathoms deep, a seam of anthracite coal, three to four inches thick, in the midst of ancient schists, probably Lower Silurian. He then referred to coaly and lignitic beds in newer formations, especially to the tertiary brown coal, which in continental, and especially in Southern Europe, attains to great importance. The excellent preservation of the vegetable remains in the lignite has enabled Unger and Heer to make accurate comparison with existing floras, and to show that the tertiary flora had nothing in common with our present flora in Europe, but an extraordinary resemblance to that of modern North America. This was especially to be noticed in closely similar species of the genera *Liquidambar*, *Liriodendron*, *Pavia*, *Nyssa*, *Robinia*, *Taxodium*, *Sequoia*, *Juglans*, *Glycyrrhiza*, *Cercis*, *Laurus*, *Rhododendron*, *Cissus*, and certain oaks and pines. There was hence no retreating from the conclusion, that at this portion of the tertiary period, a land communication must have existed between America and Europe. Fragments of that land, with relics of the same tertiary flora, still exist in Iceland and the Azores, with their *surturbrand* and lignites; and thus, that Atlantis, which is generally set down as a dream of the poets, is brought again into solid existence by the studies of the geologist. A relation of this kind at a comparatively recent period, throws a light

on the causes of phenomena belonging to an earlier epoch, and will enable us to form conclusions, if not upon the absolute contemporaneity of certain beds or groups of coal measures, at all events upon the physical connexion, within a given period, of the agencies which were forming coal not only in the various fields of Europe, but also in North America; and the speaker concluded by pointing out that the reasoning on the continuity among one another of our British coal fields, or of them with those of Belgium and North France, depends on somewhat complex data, which scientific investigation can alone afford.

On the Rigidity of the Earth. By Prof. WILLIAM THOMSON, F. R. S. (Abstract.)

The author proves that unless the solid substance of the earth be on the whole of extremely rigid material, more rigid for instance than steel, it must yield under the tide-generating influence of sun and moon to such an extent as to very sensibly diminish the actual phenomena of the tides, and of precession and nutation. Results of a mathematical theory of the deformation of elastic spheroids, to be communicated to the Royal Society on an early occasion, are used to illustrate this subject. For instance, it is shown that a homogeneous incompressible elastic spheroid of the same mass and volume as the earth, would, if of the same rigidity as glass, yield about $\frac{1}{3}$, or if of the same rigidity as steel, about $\frac{2}{5}$ of the extent that a perfectly fluid globe of the same density would yield to the lunar and solar tide-generating influence. The actual phenomena of tides (that is, the relative motions of a comparatively light liquid flowing over the outer surface of the solid substance of the earth), and the amounts of precession and nutation, would in the one case be only $\frac{2}{9}$, and in the other $\frac{2}{5}$ of the amounts which a perfectly rigid spheroid of the same dimensions, the same figure, the same homogeneous density, would exhibit in the same circumstances. The close agreement with the results of observation presented by the theory of precession and nutation, always hitherto worked out on the supposition that the solid parts of the earth are perfectly rigid, renders it scarcely possible to admit that there can be any such discrepancy between them as 3 to 5, and therefore almost necessary to conclude that the earth is on the whole much more rigid than steel. But to make an accurate comparison between theory and observation, as to precession, it is necessary to know the absolute amount of the moment of inertia about some diameter; and from this we are prevented by the ignorance in which we must always be as to the actual law of density in the interior. Hence the author anticipates that the actual deformation of the solid earth by the lunar and solar influence may be more decisively tested by observing the lunar fortnightly and the solar half-yearly tides.* These tides, it may be supposed, will follow very closely the "equilibrium theory" of Daniel

* High tide, as far as the influence of either body is concerned, is produced at the poles, and low (average) water at the equator, when its declination, whether north or south, is greatest, and low water at the poles and high water at the equator, when the disturbing body crosses the plane of the equator.

Bernouilli for all oceanic stations, and the author suggests Iceland and Teneriffe as two stations well adapted for the differential observations that would be required.

The earth's upper crust is possibly on the whole as rigid as glass, more probably less than more. But even the imperfect data for judging referred to above, render it certain that the *earth as a whole must be far more rigid than glass*, and probably even more rigid than steel. Hence the interior must be on the whole more rigid, and probably many times more rigid, than the upper crust. This is just what, if the whole interior of the earth is solid, might be expected, when the enormous pressure in the interior is considered; but it is utterly inconsistent with the hypothesis held by so many geologists that the earth is a mass of melted matter enclosed in a solid shell of only 30 to 100 miles thickness. Hence the investigations now brought forward confirm the conclusions arrived at by Mr. Hopkins, that the solid crust of the earth cannot be less than 800 miles thick. The author indeed believes it to be extremely improbable that any crust thinner than 2000 or 2500 miles could maintain its figure with sufficient rigidity against the tide-generating forces of the sun and moon, to allow the phenomena of the ocean tides and of precession and nutation to be as they are.

Proc. Royal Society, May 15, 1862.

An Ancient Baker's last Batch.

From the Lond. Builder, No. 1021.

We learn from *Galignani*, and other sources, that a curious discovery has just been made at Pompeii. In a house in course of excavation an oven was found, closed with an iron door, on opening which a batch of eighty-one loaves, put in nearly eighteen hundred years ago, and now somewhat overdone, was discovered; and even the large iron shovel with which they had been neatly laid in rows. The loaves were but slightly over-baked by the lava heat, having been protected by a quantity of ashes covering the door. There is no baker's mark on the loaves; they are circular, about nine inches in diameter, rather flat, and indented (evidently with the baker's elbow) in the centre; and are slightly raised at the sides, and divided by deep lines radiating from the centre into eight segments. They are now of a deep brown color, and hard, but very light. In the same shop were found 561 bronze and 53 silver coins. A mill, with a great quantity of corn in excellent preservation, has also been discovered.

Bank-Note Splitting

From the Mechanic's Magazine, August, 1862.

Mr. Thomas Millard, a native of Bath, now one of the Queen's bookbinders, under the librarian at Windsor Castle, has discovered a method of splitting bank notes or any other sheets of paper. By the courtesy of Mr. Gregory, of Bath street, with whom Millard served his time as an apprentice, specimens of the young man's ingenuity, consisting of a £5 Bank of England note, a sheet of the *Times*, of the *Illustrated*

London News, of the *Bath Journal*, and of the *Daily Telegraph*, each of which has been split cleanly and cleverly into two parts, without any rent or tear, have been exhibited to many of our fellow-citizens during the past week. There can be no mistake about the matter, as we have now before us a copy of a leaf of our own *Journal* completely split in two. The separate parts could well be printed on at the back, but the separation of the flimsy paper of the *Telegraph* seems equally complete. The engravings in the illustrated journal are brought out more clearly by the process, and when mounted on cardboard present a strikingly improved appearance. The discovery is applied by Mr. Millard to practical use in print-mounting, and in repairing torn leaves of books, which he can so skilfully manage that the junction of the new and old paper can with difficulty be distinguished. The mounting of the old prints upon paper is also so complete, that the specimens we have seen seem impressed upon the original paper. Unscrupulous people would certainly turn this plan of bank-note splitting to profitable account, if they could find it out, inasmuch as the halves could be made as stiff as the whole, the blank parts could be printed in imitation of the original, and the water-mark would of course be perfect. A cotemporary says that "Mr. Millard has devised a method of manufacturing paper that cannot be split, and bankers will probably soon be compelled to make use of his invention;" but this we understand is a mistake. Mr. Millard, to prevent the difficulty which might arise to the Bank of England for having their water-mark left on blank pieces of paper, upon which might be printed *fac similes* of their notes, suggests a plan for the prevention of the fraud. We are glad to hear that Her Majesty, in consideration of the talent displayed by Mr. Millard in this discovery, has already been pleased to order that he should have an increased salary. We hope that this discovery may further lead to his pecuniary advantage.—*Keene's Bath Journal.*

History of the Manufacture of Instantaneous Light.—Extracted from a Lecture by Prof. LYON PLAYFAIR, before the Royal Institution of Great Britain, June 5th, 1862.

From the London Chemical News, No. 137.

I cannot tell you who was the first inventor of a means of getting instantaneous light. Many admirers of Prometheus declare that it was Prometheus, but he does not do so himself. He says this:—

> "I am he who sought the source of fire,
> Enclosing it hid in my narthex staff;
> And it hath shown itself a friend to man,
> And teacher of all arts."

You recollect the circumstances under which Prometheus got the fire. Jupiter was so angry with Prometheus for having stuffed a bull's skin with bones and passed it off as a real carcase for a votive offering, that he took away fire from the earth to punish Prometheus. We might suppose that the father of the gods removed the fire lest the ingenious

Prometheus should have made phosphorus from the bones, and thus become independent of the gods. Whether man would thus have been independent of the gods for fire I do not know, but fire was taken from the earth. What Prometheus actually did was only to steal fire from the chariot of the sun and keep it alive, until he reached the earth and gave it to man, by blowing it with the pith of the giant Fennel, which he used as a staff. We are told by Pliny and Virgil that the tinder-box, similar to those used by us, was well known in their time. They describe the properties of the flint and steel, and Virgil says that dry leaves may be ignited by means of the flint and steel with the rapidity of speech. The savages of various countries found for themselves a means of getting a light, which was far from instantaneous. I think that it would require much more dexterity than we can employ, to demonstrate how a light may be got by rubbing together two pieces of wood; but we can get sufficient heat in that way to ignite some substances which are more combustible than the wood itself. Mr. McIvor will rub these two pieces of wood together, and you see that in a little time they become very hot. Now they are smoking violently. Observe that there is now heat enough to ignite a piece of phosphorus readily. In this case the friction by a philosophical process, which I need not describe just now, is sufficient to produce a large quantity of heat; and savage tribes have been accustomed to use that friction to obtain a source of light. For a long time, as many of my older hearers will recollect, our only means of obtaining an instantaneous light, even within my own recollection, was the tinder-box. The tinder-box with its trio was familiar to many of us—burnt-rag, flint, and steel. These were used to obtain a flame, and then in addition to this trio there was the sulphur-match, which was ignited after the flame had been obtained by the sparks falling among the burnt-rag. If the rag were not damp, and every thing was in perfect order, you could get a light in a short time; but if the rag were at all damp, or the day was drafty, you might get a light perhaps in a quarter of an hour. [The lecturer here illustrated the use of the tinder-box.] There, now we have got a light, and by blowing it up I may succeed in getting the sulphur-match alight. I recollect when I was a boy remaining for at least half an hour in a castle which I was to be shown over, whilst a light was got in this way. Tedious, however, as this process is, I find that there are even in London at this very moment some venerable ancients who still use nothing but the tinder-box as a means of obtaining a light. I bought this specimen in the Edgware Road, and I was assured by the shop-keeper that there was still a steady though not brisk sale for this antiquated contrivance, and that notwithstanding lucifer-matches there are several who resort to this mode of obtaining a light.

The first invention which led the attention of chemists to the importance of a means of obtaining an instantaneous light occurred in 1820, when Dobereiner produced a lamp of an elegant character. You will see it represented in this diagram. Here is a vessel in which hydrogen gas is collected. The hydrogen gas is formed by the action of sulphuric acid and water upon zinc. These acting upon the zinc produce

hydrogen, and the hydrogen rises here, and as it is formed it expels the acid from the vessel, so that it no longer acts upon the zinc. I have in this way a reservoir of hydrogen; and now if I take a piece of spongy platinum, which has the power of absorbing oxygen from the air and condensing it within its pores, and bring this platinum in contact with the hydrogen, you see that it gets red hot, and ignites the hydrogen. Thus, you see that this plan of applying hydrogen for the purpose of acting upon the oxygen condensed in spongy platinum is a method by which a light can be obtained. The spongy platinum absorbing oxygen, presented oxygen to the hydrogen, and caused the formation of water, and in the formation of water so much heat was produced that the hydrogen became ignited, and a light was obtained. One disadvantage which prevented it being universally adopted was simply this: that the least speck or fouling of the spongy platinum puts the lamp out of order. For instance, this may have been in order five minutes ago, and it may be out of order now. Some dust or dirt may have got upon the spongy platinum. Still, the application was so elegant that it drew the attention of scientific men to the importance of getting an instantaneous light.

The next invention consisted in mixing phosphorus and sulphur in a bottle, and then taking them out upon a splint of wood, which was rubbed, and a light obtained in that way.

Then came the method of getting a light by means of chlorate of potash and sulphuric acid. Here I have some chlorate of potash mixed with sugar, and I place a little of it on a plate. I will not put too much because of the fumes. I now dip this rod in sulphuric acid so as to get a little on the end of it, and with this I touch the mixture of chlorate of potash and sugar. The sulphuric acid liberates the chloric acid, which gives oxygen to the sugar; the sugar burns, and an instantaneous light is obtained in this way. Captain Manby used this process for firing off his safety mortars, and thus drew considerable attention to this mode of obtaining a light. An application of this chlorate of potash and sulphuric acid to match-making was now made. There were two applications; one was older than the other. The method which was first introduced consisted of having a little bottle of asbestos. Here is one of the old kind, which many of us recollect. This asbestos is moistened with oil of vitriol, and the chlorate of potash and sugar, instead of being separate, as I showed you there, are put upon the end of the match, and you dip it in the sulphuric acid, and the chlorate of potash and sugar mixture gets ignited, and the light is got in that way. Well, that was the first application of the old experiment of chlorate of potash and sugar. Then there was another. I am sorry to say that I have only one or two of these ancient matches left, and they will soon be gone altogether. The plan was to take the chlorate of potash and sugar, and wrap it up in a piece of paper, and to have the sulphuric acid sealed up in a little glass globule inside the mixture. The mode of using it was, if you had a pair of pincers at hand, to break the globule with them, and so ignite the match; but if you had not a pair of pincers in readiness, you did it

between your teeth; and if you were very clever, you might do it without getting the sulphuric acid into your mouth, or burning it with the explosion. This match had a great objection—that chlorate of potash and sugar always go off violently, and the sulphuric acid in the globule, although in small quantity, was spirted over the dress, and destroyed the dress whenever it came in contact with it.

The first friction-match was introduced in 1832. The mode in which these friction-matches were made, many of my hearers who lived in 1832 will recollect. I have a lively recollection of it. The mode was this—sulphide of antimony was mixed with chloride of potash. Here the sulphide of antimony gave sulphur, just as the sugar gave a combustible to the chlorate of potash. This was put upon the end of a piece of wood, and the friction was produced by drawing this through a piece of sand-paper. I have here some antique matches of all kinds, which are now very valuable because they are very difficult to obtain. My experience as a boy with regard to these friction-matches was that with considerable adroitness you might get a light after pulling off the ends of half a box; and then when it did come, it came with such violence and explosion that it projected a considerable quantity of the ignited matter over the hands and burnt them. You might get a light for 6d. or 3d.; at least, that was my experience as a boy. My seniors may have been more successful.

In 1834 the phosphorus-match was invented. In this, after a time, sulphur became substituted for sulphide of antimony, and it was a great improvement upon the old congreve. At first the phosphorus-match was violent in its action, and it projected its melted materials over the fingers unless you held it carefully, and the reason of that was that nothing but chlorate of potash was used as the oxidizer. The friction produced the heat necessary to ignite the phosphorus; the chlorate of potash gave it the oxygen, and it burnt violently. After a time manufacturers learnt that it was better not to take chlorate of potash by itself, but to mix it with some less energetic oxidizing agent, —as, for instance, with saltpetre or nitrate of potash, or with peroxide of lead, or with some agent less energetic than the chlorate of potash. In this way the phosphorus-match became much improved in character. The sulphur which was used to carry out combustion, and to get up sufficient heat to make the wood ignite, was also gradually substituted in the better kind of matches by melted stearine. The wooden match was dipped into melted stearine, and all possibility of fumes of sulphur was in this way obviated. The common phosphorus-match became gradually improved, and its use has now increased to such an extent, that it may surprise you to know that there are some chemical works in this country where they make nine million of matches daily. In France and England alone 300,000 pounds of phosphorus are annually made into matches, and as three pounds of phosphorus are sufficient to tip five or six million of matches, you can conceive what a large industry this has become. But the larger the industry has become the

greater has been the evil with regard to the workers. On account of the extreme cheapness of the phosphorus-matches there is a desire to make them of the cheapest materials, and as this waxy phosphorus is cheaper than this allotropic phosphorus, all the common matches are, of course, made with the ordinary phosphorus. I show you a better kind of matches, which I hope all my hearers will encourage, which are not made with the waxy phosphorus, but with the allotropic, or brown phosphorus. You may easily know them by their brown ends. The allotropic phosphorus fortunately answers equally well for the purpose, and is not at all poisonous to the match-makers who have to use it. There are two kinds of matches made with the allotropic phosphorus. One kind is made like the ordinary match, with the oxidizing material, and the allotropic phosphorus mixed together and put upon the end of the match. It, therefore, differs from the ordinary kind only in the fact of its being made with allotropic phosphorus. But there is another kind of match which has been manufactured, and it is an exceedingly beautiful invention. Here the oxidizing material alone is put upon the match, the phosphorus not being put upon the wood. It is not, therefore, a match of the ordinary kind. You could not get it to ignite in the usual way. Here the oxidizing material is put upon the piece of wood, and the allotropic phosphorus is put upon the friction-paper mixed with the emery. This piece of wood does not, therefore, become a match until I take off a certain quantity of that phosphorus along with my oxidizing material, by rubbing it upon the paper upon which the emery and phosphorus are spread. The value of that device is great, because there can be no accidental firing, as in the ordinary matches. Trampling upon them, or leaving them too near the fire, cannot make them ignite, because the match is not a match until it is drawn over the sand-paper and takes up phosphorus. Accidental ignition is thus prevented.

I now see that my hour is exhausted, although my subject is not; and I can only conclude by stating generally that although you may consider the rather multifarious waste materials which we have brought together and viewed in their general application to industry as at first sight apparently repulsive, they lose entirely their repulsiveness when you see them converted into these elegant utilities. Even those rags which are made into these beautiful cloths, or the cotten rags which are made into paper, have all undergone such a complete purification, and such thorough changes in their progress to utility, that they may be worn or used with perfect safety, and they produce utilities which are even elegant in their character. Therefore I trust that I have shown you that chemistry in its economy produces objects of great value from the most waste materials. I am going to ask you in my next lecture to follow me in what Nature does in the same way, and to show you that Nature allows nothing to be wasted, and that all those substances which we regard as waste and repulsive become useful materials under the transforming influence of natural causes, and that thus nothing is lost in the economy of the universe.

On an Electric Light Regulator. By M. SERRIN.

From the Lond. Mechanics' Magazine, August, 1862.

The electric light is quite a modern discovery. About the year 1730, when it was first observed in England, it was possible to obtain only a few phosphorescent gleams. In France, in Dufay's hands, these gleams became sparks darting from the body and face of an electrified person. These sparks then shone brighter in the Leyden jar, and, as the machines became more perfect, gradually developed into two great discoveries of the age—the voltaic pile and electro-magnetic action; so that by means of electricity we now obtain the most dazzling light and the intensest degree of heat. Hardly thirty years since, the luminous and calorific effects of powerful batteries were first studied, and contrivances are already devised for the purpose of rendering these effects continuous and constant. M. Serrin's regulator, which we propose to describe, is one of the latest inventions, and is distinguished by new and ingenious solutions of the chief difficulty of the problem.

Before describing the mechanism which gives a distinctive character to M. Serrin's regulator, let us briefly indicate the general conditions which a regulator of the electric light ought to fulfil.

There must be a pile having at least 50 Bunsen's elements of ordinary size to produce a good light. 100 elements united in tension give a more brilliant light; but this, again, is far surpassed by arranging them in two batteries each of 50 elements, so as to produce quantity.

It is well known that the current produced by such batteries is in some degree like the lightning's stroke, and that there is real danger in closing the circuit by touching the positive pole with one hand and the negative pole with the other. Nevertheless, this energetic power, incessantly reproduced, manifests its presence by no external sign, whilst it is propagated through a circle formed of thick metallic wires. It shows itself with violence only on closing and breaking the circuit. If sharply closed, only a bright light is seen; if the circuit be suddenly broken, a bright light is also visible, generally of a different aspect; but if the two wires, or rather the two bodies which should complete the circuit, are made to approach each other, so that the circuit, precisely speaking, is neither wholly opened nor wholly closed, then the double phenomenon becomes permanent and the light extremely brilliant. No matter can resist this heat incessantly renewed, which is maintained as long as the action of the pile lasts—that is to say, for days together.

Thick rods of gold, iron, and platinum melt like sealing-wax, and their vapors give various colors to the luminous envelopes which seem to unite the two poles. Silica, alumina, and the greater number of the most refractory substances, taken separately, are alike fused and volatilized. There is, however, one substance—the only one, perhaps—which in some degree resists the action of this furnace, and which, by a conjunction of favorable circumstances, is a good conductor of electricity (a condition indispensable to the object in view), can be fashioned in any form, and is, moreover, neither rare nor dear. This body is charcoal, such as concretes in gas retorts, or which can be prepared

in pieces by particular processes. Round or square perfectly even rods are made of it, about 30 centimetres long, and varying in thickness from 5 to 10 or 12 millimetres. Two of these rods are adapted at one of their extremities to suitable metallic pieces, one terminating the positive wire, the other the negative wire of the pile. These wires of good red copper, from 3 to 4 millimetres in diameter, covered with silk or cotton, may be several hundred metres, or even several kilometres long, according to the distance between the pile and the extremities of the wire. The positive and negative charcoals are generally superposed vertically. Were their free extremities planed and placed in perfect contact, the current introduced by means of the commutator would not manifest itself; it would pass into the charcoal as into the copper wire, without giving any outward sign of its presence. The circle would be completely closed.

But if in the apparatus or regulator containing the charcoals there is an electro-magnet provided with a movable armature conveniently disposed, the passage of the current would cause the armature to fall, and this movement communicating itself, for instance, to the supporter of the lower charcoal, would depress it from two to three millimetres, whilst the supporter of the upper charcoal remains fixed. It is clear that the free extremities of the charcoal being no longer in contact, the circuit will be broken, light will burst forth, and that the phenomenon will persist, under the single condition that the circuit is neither completely closed nor broken—that is to say, beyond the limits which the current can traverse.

The better to appreciate other phenomena, let us now carefully examine the effects produced on the charcoals.

Charcoal resists fusion, but it is acted on by a kind of molecular disintegration, which rapidly wastes it, the result either of the simple action of the intense heat or the current itself, which tears off and transforms the last material particles. The wear is unequal, that at the positive being generally about twice as great as that at the negative. The combustion of charcoal by the oxygen of the air is of little account, for no marked difference is observable when the charcoals are kept in an atmosphere of nitrogen. It will be observed that the incandescence of the positive pole occupies more length than that of the negative, as if the latter underwent a less degree of heat. In consequence of this destructive process, the space between the two charcoals becomes in a few minutes enlarged. At first only two or three millimetres, the distance soon increases to eight, ten, or even more, according to the nature of the charcoal and the force of the current.

To observe these phenomena to the greatest advantage, we must project on to a screen the image of the charcoals magnified eight or ten times, when the light becomes supportable, so that observers can study with facility the series of appearances which present themselves in this focus of light and heat, apparently so constant, yet so agitated. We cannot now enter into the details of the curious observations which have been made on the impurity of charcoals, on the coloration of the flames by the substances introduced into them, on the fusion of bodies

placed, not in contact with the charcoals, but in the intervening space. We will confine ourselves to stating that the intensity of the light is notably diminished by a kind of waster, which forms from time to time on the point of the negative charcoal by the accumulation of particles from the positive charcoal, as if by the current. These wasters disappear and reappear at intervals, but they are very rarely observed with certain charcoals and at certain degrees of intensity of the pile; consequently, careful selection of the charcoal must be made in order to secure a more constant light.

The interval between the positive and negative extremities cannot be indefinitely increased in the regulator, and for two reasons:—1. The intensity of the current diminishes in proportion to the extent of this interval. 2. The intensity of the light diminishes with the force of the current. It is necessary, then, to limit the increase of the space to prevent the diminution of the light. This is one of the most important and one of the most delicate functions of the regulator; and for this purpose M. Serrin's mechanism is unrivalled in ingenuity. It is evident that the electro-magnet previously mentioned is the regulator of the motive power to coadapt the charcoal; but this adaptation is a very complex process. 1. The centre of the focus of light must remain at the same level. 2. The charcoals must not come into contact, as the circuit would then be completely closed and the light extinguished, at least for a moment. 3. The movement must be made exactly at the right instant; that is to say, before the current has undergone a certain, hardly perceptible, diminution.

It is especially in accomplishing the last condition that M. Serrin's regulator acts with unequalled precision.

The armature of the electro-magnet can be likened to the scale of a balance with a fixed weight, of which the balancing space is limited to 3 or 4 millimetres by tangent screws, and which, instead of having counterweights on the other side, are supported by two springs, one fixed nearly in equilibrium, while the other receives a variable tension by a movement of the screw. Such a scale is easily made to descend by the superaddition of 10, 20, or 30 grammes, according to the degree of tension to be given to the second spring. Such is the principle on which M. Serrin has formed his ingenious apparatus. His armature is connected with all the supports of the negative charcoal, and oscillating vertically and freely within the narrow limits of 3 or 4 millimetres, the two springs keep it raised, and the superaddition making it descend is the attractive force of the electro-magnet. This force decreases with the force of the current; consequently it decreases when the charcoals, from being worn away, leave too great a space between them, and the light begins to fade.

The variable tension of the spring is, in fact, regulated by this datum. The instant this minimum is reached the scale ascends; that is to say, the spring raises the armature, the surcharge due to the electro-magnetic force having become insufficient to restrain it.

These improvements seem to us all the more important, since M. Serrin, in constructing his regulator, has succeeded in uniting the

freedom and accuracy of the automatic movements with a solidity which excludes all accidental causes of derangement.

We have proved that this apparatus is not less fitted to receive the induced current proceeding from powerful magneto-electric batteries set in motion by a steam engine of three or four horse power. In this case, the current is not continuous, but alternately positive and negative. There is no need of much complication in these batteries to rectify the current, leaving it in its original uncontinuous state; but in this case rectification is useless, the regulator adapting itself perfectly to the disconnectedness and to the alternation.—*Comptes-Rendus.*

The Fatal Boiler Explosion near Wigan.

From the Lond. Mining Journal, No. 1409.

The inquest on the bodies of Robert Hilton and Peter Chadwick, two men killed by the explosion of a boiler at the Scott-lane Colliery, Blackrod, near Wigan, worked by Messrs. Woods and Son, was resumed on Monday, before Mr. Price, deputy county coroner. The boiler was one of a series of six, placed down, according to the evidence of John Smethurst, the colliery manager, five years ago. The boilers were all new, were made by the Haigh Boiler Company, and were considered of excellent construction. The exploded boiler, situated close to the colliery, was used for the purpose of winding coal during the day, and for pumping during the night. On the evening of the 9th inst., about 9 o'clock, Robt. Hilton (the engine-tender), Wm. Hunter (the fireman), and Peter Chadwick (a farm laborer), were seated in the fire-hole, immediately in front of the boiler, which was one of the pair in the centre of the half-dozen above named, and of an egg shape, when it exploded. One of the plates near the fire-hole was forced completely off, and the boiler was divided into two portions, one of which was thrown into the fire-hole, and the other, about 4 tons in weight, was forced against the chimney in connexion with the boiler, which was knocked down by the concussion. The brickwork was scattered in all directions, doing considerable damage. The engineer was killed on the spot, and Chadwick, who had visited the works for chat and pastime, was so severely injured that he died on the following day. The fireman escaped with some serious injuries, from which he had so far recovered as to be able to give evidence at the opening of the inquest on the 11th inst., when he stated that on the Thursday evening he examined the water-gauges and safety-valves on the six boilers, and found them all right; and Hilton, the deceased engineer, examined the gauges a few minutes before the explosion. The glass on the boiler which exploded showed 6 ins. of water, which made 18 ins. above the fire. The inquest was adjourned for the attendance of Mr. Dickinson, the Government Inspector. Smethurst, the manager, said Hllton was a very careful and experienced man. Seven months ago the exploded boiler was repaired by Messrs. Scholes and Schofield, of Wigan. They put in two new plates over the fire-place, in two sepa-

rate laps, but adjacent to each other. The boiler was worked at a pressure of from 40 to 50 lbs. to the square inch above the atmospheric pressure, and was supposed to be able to stand a pressure of 150 lbs. He was of opinion that the cause of the boiler exploding was from the iron between some of the rivets having corroded, and that the corrosion had been going on for some time.—Mr. Joseph Dickinson, Government Inspector of Coal Mines for this district, said: On Monday, the 11th inst., he examined the boiler which exploded at the Scott-lane Colliery, and found the state of things as described by the witnesses, and, so far as his examination of the material used went, he saw no cause to account for the explosion. He detected no corrosion or anything from which it could be said that there had been any unperceived crack going on. On consideration, however, he thought that such might have been the case. As to the steam-gauges, they were not, perhaps, in accordance with the strict letter of the Act regulating coal mines, that Act requiring that there should be a steam-gauge attached to each steam-boiler. When that Act came into operation, it was the exception, not the rule, to find any steam-gauge whatever attached to colliery steam-boilers; and, although not strictly literal, it had been held that, when the boilers were attached to a proper gauge by a pipe specially for that purpose, and not on the steam-pipe which supplied the engine, it was sufficient compliance with the requirement of the Act. In this instance, the boilers were fitted up with greater care than was to be met with in the majority of collieries; and the late explosion he should attribute to pure accident. He should regret, however, to see it put down in the list of mysteries, so often attributed as the cause of boiler explosions. There must be a cause, and he was of opinion that the sooner they ceased to be looked upon as mysteries the sooner the true cause would be ascertained. Up to the present time it had been looked upon by the boiler makers, well known and of good standing, and also by many of our leading engineers, that the thickness of the plates of similiar construction to the exploded one was quite sufficient for the pressure which it had to bear, and he did not feel himself at liberty to set his individual opinion against such concurrent testimony. He had, however, given the subject some attention, and he found that, although such a construction of boiler is admissible in this country, it was prohibited by law in Belgium. He had a copy of the laws under which the mines in Belgium are required to be worked (*Nouveau Code des Mines*, 1846, *et Supplement*, 1852), and he found that the thickness to be given to the plates of cylindrical boilers is expressed by the formula $T = D(P-1)\,1{\cdot}8+3$; T being the thickness expressed in millimetres, D being the diameter of the boiler expressed in metres, and P pressure of the steam expressed in atmospheres (the pressure of steam in the boiler being one atmosphere above that usually indicated by steam-gauges in England). By this formula, he found that the plates for the exploded boiler ought to have been 0·46 of an inch in thickness, when in reality they were only 0·375. The Belgian law also prohibited any boiler from being worked with plates of a

greater thickness than 14 millimetres, which is equal to about 0·55 inch. With measures in English, he had a made a formula, which gave similar results to the Belgian one, the formula being as follows: $\frac{T = (D \times P) + 98}{750}$; T being the thickness of the plates in inches, D the diameter of the boiler in feet, P the pressure of steam above the atmospheric pressure. Applying this to the exploded boiler gives $\frac{5 \times 50 + 98}{750} = 0{\cdot}46$ inch as the thickness which the plates should have been (or the same as with the Belgian rule), instead of 0·375, the thickness of the plates of which the boiler was made. He gave this Belgian law, as it was manifestly at variance with the thickness at which boilers are worked in this country, and he trusted that the matter would receive further attention from our engineers, as it might result in uniformity of practice. In the manufacture of iron, it was impossible to get plates always of a uniform strength, and it was always better to have the plates a little stronger, to meet such cases as the one under notice, it being quite possible that the very large margin which engineers allow for safety is not sufficient, and may be the cause why so many explosions take place without any assignable reason. The practice of piecing boilers must also tend to cause a difference in the contraction and expansion of the new and old parts. Making them partly of Low Moor, and partly of a different kind of iron, will also give rise to different amounts of contraction and expansion, which might be avoided if boilers were constructed of uniform quality and thickness.

The jury expressed themselves fully satisfied with the explanation given, and returned a verdict of "Accidental Death."

—

Table of Thicknesses for the Plates of Cylindrical Boilers of Iron or Copper, calculated according to the Belgian and Mr. Dickinson's Formulæ, as given in the above evidence.

Diameter of Boiler.	Pressure of steam in the boiler, being the pressure over and above the atmospheric pressure, per square inch.									
	10 lbs.	20 lbs.	30 lbs	40 lbs.	50 lbs.	60 lbs.	70 lbs.	80 lbs.	90 lbs.	100 lbs.
Feet.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
3	0·17	0·21	0·25	0·29	0·33	0·37	0·41	0·45	0·49	0·53
4	0·19	0·24	0·29	0·35	0·40	0·45	0·51			
5	0·20	0·27	0·33	0·40	0·47	0·53				
6	0·21	0·29	0·37	0·45	0·53					
7	0·23	0·32	0·41	0·51						

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, Nov. 20, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Society and the Society of Arts, London; the Smithsonian Institution, Washington, D. C.; the Regents of the University of the State of New York, Albany, and the Chamber of Commerce of the State of New York, City of New York; W. H. B. Thomas, Esq., Mount Holly, New Jersey; and Philip Price, Esq., and George M. Conarroe, Esq., Philadelphia.

A donation to the Cabinet of Models was received from G. Tagliabue, City of New York.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of October was read.

The Board of Managers and Standing Committees reported their minutes.

Several resignations of membership in the Institute were read and accepted.

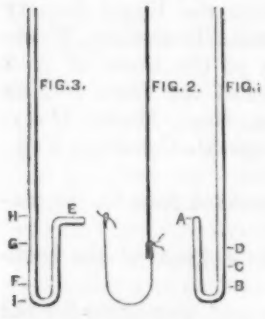
Candidates for membership in the Institute (15) were proposed, and the candidates (6) proposed at the last meeting were duly elected.

Mr. Warren Rowell, of New York, addressed the meeting on the subject of Superheated Steam as follows:

Some years since, Mr. James Frost, of Brooklyn, N. Y., advanced the theory that a cubic inch of steam when heated apart from water increased to two cubic inches by the addition of 4° of heat, that is, a cubic inch of steam formed at 212° Fahr., increased to two cubic inches at 216° Fahr., and then by the addition of 12° more, the volume was increased to three cubic inches; or in other words, three times the power was obtained by this superheating with the addition of 16° of heat. This supposed elastic vapor he called *stame*. The experiments of Mr. Frost were examined and reported upon by a committee of the American Institute of New York, composed of Professors James Renwick, H. Meigs, and H. R. Dunham. The committee in their published report say:—"The experiments described by Mr. Frost, of which a sufficient number were witnessed by the committee, enable them to assert that there is no reason to suspect *any fallacy* in their results. * * * * * That previous to the experiments of Mr. Frost, it was held and admitted by all scientific men that the vapor of water obeyed the law of Gay Lussac, that it increased in volume $\frac{1}{480}$ for every increase of 1° Fahr. The accuracy of this law has recently

been called in question. * * * * * The experiments of Mr. Frost under consideration show that it is *very far* from being true in regard to dry steam," &c. The following experiments are intended to show that Mr. Frost was simply mistaken:

I have here a bent glass tube like the annexed drawing (fig. 1), the long arm of which is 12 inches long, and the short one 3 inches, with from $\frac{1}{4}$ to $\frac{3}{8}$-inch diameter of bore, and closed at the short end, A. In preparing the tube after the directions of Mr. Frost, I put in a drop or two of water, and allow it to flow to the closed end, A, of the tube by tipping it up. Then I put in mercury enough to fill it from the point A to B. The tube is now placed in a saturated solution of boiling salt water of 228° F., so that the point of the tube, A, will be about one inch below the surface. In a short time steam will be formed in the point of the tube at A, and displace the mercury from the short leg, and the excess of water converted into steam will escape past the column of mercury in the long leg of the tube; it will take some time for the excess to boil out. The tube is then lifted out of the boiling water, and an inch of mercury is added, filling the tube to the point C. If you place the tube in boiling water at 212° F., there will be one inch of steam in the short leg of the tube. If you now add salt little by little until it takes 216° F. to boil it, there will be two inches of steam in the tube; then keep adding salt until the water is saturated and boils at 228° F., and there will be three inches of steam in the tube. Thus showing, according to Mr. Frost's theory, the addition of two inches of steam by the 16° addition of heat.



Now I take a tube just like the one described, and fill it with mercury to the point C. I then take a small wooden rod, smaller than the bore of the tube, about 12 ins. in length, with a piece of flat platina wire about $\frac{1}{50}$th of an inch in thickness, $\frac{1}{16}$th of an inch in width, and 5 ins. long, and attach it to the rod with a piece of thread (like fig. 2); the free end of the wire I bend over so as to make it hold a piece of fine sewing cotton about $\frac{1}{8}$th of an inch in length; this cotton thread is wetted in water, and thrust down through the mercury in the tube up to the point A, the capillary attraction of the thread preventing the pressure of the column of mercury from displacing the water. I now place the tube in the boiling salt water at 228° F.; as soon as an inch of steam is formed I withdraw the wire quickly. It is somewhat difficult to get the exact quantity of water to make an inch of steam without two or three trials. Having obtained the inch of steam at 228° F., now place the tube in boiling water at 212°, and you have an inch of steam less the difference in volume for the difference of heat, according to the law of Gay Lussac and of Dulong and Petit, or about one-thirtieth of an inch diminution in volume. Thus showing that Mr. Frost had in his tube more water than would make an inch of steam at 212° F.

To show still further the fallacy of this "stame," I take a tube like fig. 3, having the short leg 4 inches long and 1 inch bent over at a right angle, and filled with mercury to the point F. Now, I wet the thread on the end of the wire, thrust it through the mercury to the short bend, and put it in boiling water at 212° Fahr., and in a few minutes you will have two inches of steam in the tube, and the mercury is in equilibrium. I now put two inches more mercury in the tube to the point G, and on placing it in the boiling water you will have only one inch of steam filling the short bend, and the mercury is still in equilibrium. I then fill the tube with mercury to the point H. Now put it in boiling water, and it might be kept there a long time without making any steam at all, showing how fine a point there is between steam and water. Again, I place the tube in boiling salt water at 228° F., and you see that the tube is filled with steam to the point I, making 5 inches steam. Thus conclusively showing that Mr. Frost had more water than would make an inch of steam at 212° F., and that his tube was simply a mercury steam-gauge, and only wanted the additional heat to give it the additional pressure and volume.

The idea of wetting a small piece of thread, and thrusting it under a column of mercury, is, I think, an entirely new way of getting a specific amount of water under pressure, and enables any one to ascertain all the facts in regard to the law of the increase of the volume of steam by the increase of heat with perfect success.

By these demonstrations you will see why there have been such small results from the attempts at superheating, while so much was expected. The reason for using a platina wire in the foregoing experiments is, that the mercury does not amalgamate with it, and an iron wire would scratch the glass tube, and render it liable to crack by the changes of temperature.

Dr. G. Emerson exhibited a number of specimens of Cotton on the stalks, and made the following remarks:

In a pamphlet published by me last Spring, on "Cotton in the Middle States, with directions for its easy culture," I stated that this plant, which has played such an important part in our history, was first introduced into this country and came into notice on the Peninsula between the Delaware and Chesapeake Bays, in about the 39th degree of latitude. From hence it passed into Western Maryland and Virginia, and so went South, where its culture ultimately became enormously developed. Though never entirely given up in the lower counties of Delaware and Maryland, the culture was always limited to what was wanted for domestic use. I have frequently seen families who came from those counties, with their dresses and bed clothes made of cotton of their own raising, spinning, and weaving. I therefore knew that cotton had been raised in this portion of the Middle States, and could be raised again, at a time when it would pay better than any other crop. Having land in the lower part of Kent County, Delaware, which I thought well adapted to produce cotton, I determined to make an experiment. I succeeded in obtaining through the Patent

Office at Washington, enough seed to plant several acres. This was procured from North Carolina.

I also obtained from a friend in this city a small quantity of seed from Tennessee, and was so fortunate as to get a handful from a poor colored man, who had raised a small patch of cotton in 1861, near Camden, Delaware. This last seed had become acclimated to the place where I intended planting it, as the colored family had cultivated cotton from time immemorial, using it for their clothing.

In the middle of May I planted the three kinds of seeds mentioned. All were of the Upland or Green Seed short staple varieties. The wet and cold Spring, which all must remember, was very unfavorable to the young cotton, the tenderness of which plant, when young, exceeds that of all others put into the open field. It seems to be extremely averse not only to cold air, but to water, and hence where I put it upon tenacious soil, where the water could not pass through quickly, the young cotton was killed. Much of my seed was unfortunately put in unfavorable situations, where it shared the same fate as corn similarly placed. Thousands of acres of corn have been this season destroyed on low lands, in consequence of the excessive rains of Spring and early Summer. I found this year little difference between the stand of cotton and corn. Where planted on an open and dry soil, both succeeded equally well; and where placed in unfavorable situations, both perished. The early working of both crops even in the best locations, was interfered with by the frequent and successive rains. But notwithstanding these drawbacks in the early part of the season, the cotton developed well when on suitable land, and has required no more care than corn, scarcely as much. On the 19th of July, nearly two months after planting, the cotton was only 6 to 9 ins. high. The first flowers I observed on the Tennessee and Delaware on the 12th and 13th of August. These speedily fell off, leaving young bolls at the bottom of their calices. In the middle of September the Tennessee plants exhibited great vigor, some of them being over five feet high, filled with long side branches, the bolls on some of which were nearly the size of hen's eggs. The plants continued their slow process of flowering and putting out new bolls until killed by severe frosts, Oct. 21st. The first bolls opened on the Delaware cotton on the 5th of October. Those on the Tennessee and North Carolina did not begin opening until about the 20th of October. They are still opening on the branches, and I expect to be picking out the cotton till Christmas. The yield has exceeded my expectations, the bad effects of an unpromising Spring having been more than compensated by an unusually favorable Autumn. I am not able to say how much I shall obtain from an acre of North Carolina cotton, but think it may be equal to what is usually gathered from average lands in the State from whence the seeds were procured. I have no fear of losing by my first trial, even if cotton falls to one-fourth its present exorbitant price. The experience I have gained affords in itself an ample compensation for the outlays and trouble, as it has shown me what may be done another year to secure much better results. I am clearly of the opinion that

for some years to come small crops of cotton may be raised to great profit by farmers in the southern portions of the Middle States, where the soil is favorable to the development of the plant. Should this course be extensively adopted, the amount produced by numerous farmers raising small crops, and with but little interference with ordinary farm work, would result in a large aggregate, which would do much towards relieving the country from the disastrous effects of a sectional cotton monopoly.

The qualities of my cotton have received the highest commendation from cotton merchants and manufacturers. One of these from Boston says:—"The samples of cotton I have shown to many good judges, and they were all much pleased. All pronounced the samples to be quite equal to the best of Upland Georgia cotton. I have bought cotton pretty largely for several years, and I do not remember to have seen any Upland cotton superior in length, strength, and fineness of staple."

The aids furnished to agriculture in general by modern discoveries of concentrated manures, promise great assistance to the cotton grower in the Middle States. Some of these exert a remarkable effect in hastening the maturity of crops. One which I have been using extensively for many years has always caused my corn to ripen at least a fortnight earlier than it would on ground where none was applied. The same effect must doubtless be exercised upon cotton, and I think two weeks earlier maturity may be claimed from such agency. This would raise the limits of the cotton culture at least one degree of latitude. My experience the present season justifies this conclusion.

Mr. Howson, of the Committee on Meetings, exhibited a Family Bible, published by C. H. Yost, of this city. Adjacent to the pages usually bound in the book for the registration of births, deaths, &c., are arranged in sheets any convenient number of card cases, such as contain the ordinary photographic albums, in which may be inserted the photographs of the different members of the family.

Mr. Turner Hamilton exhibited a number of postage stamp Porte Monnaies, manufactured by himself, in a variety of styles.

A patent Coal Oil Pyrometer, invented by G. Tagliabue, of New York City, was exhibited. The vessel containing the coal oil, the quality of which is to be tested, is placed in a reservoir of water, which is heated by a small spirit-lamp. A thermometer, the bulb of which is immersed in the oil, indicates the temperature. Openings in the lid of the vessel containing the oil are provided with lids, which are removed at the proper time to admit atmospheric air, which, combining with the gas generated from the oil, form an explosive mixture. A taper is introduced from time to time into a tube projecting from the top of the vessel, and when the gas and air have combined in the proper proportion, the mixture is ignited by the taper and explodes, the height of the thermometer at the moment of the explosion indicating the quality of the oil.

A Comparison of some of the Meteorological Phenomena of OCT., 1862, *with those of* OCT., 1861, *and of the same month for* TWELVE *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	October, 1862.	October, 1861.	October, 12 Years.
Thermometer—Highest degree,	86·0°	88°	90·0°
" " date,	8th	6th	4th, 1858
" Warmest day—Mean,	76·5	78·3	78·3
" " " date,	4th	6th	6th, 1861
" Lowest degree,	35·0	34·0	28·0
" " date,	28th	28th	25th, 1856
" Coldest day—Mean,	43·0	43·5	35·8
" " " date,	27th	28th	27th, 1859
" Mean daily oscillation,	15·31	16·94	15·73
" " " range,	5·48	5·28	5·55
" Means at 7 A. M.,	52·70	54·32	51·40
" " 2 P. M.,	64·29	66·61	63·43
" " 9 P. M.,	56·98	58·69	55·62
" " for the Month,	57·99	59·87	56·82
Barometer—Highest—Inches,	30·201 in.	30·452 in.	30·452 in.
" " date,	24th	25th	25th, 1861
" Greatest mean daily press.,	30·118	30·378	30·378
" " date,	24th	25th	25th, 1861
" Lowest—Inches,	29·307	29·469	29·012
" " date,	27th	30th	26th 1857
" Least mean daily pressure,	29·492	29·526	29·059
" " date,	27th	30th	26th 1857
" Mean daily range,	·151	·166	·146
" Means at 7 A. M.,	29 865	29·945	29·931
" " 2 P. M.,	29·825	29·893	29 889
" " 9 P. M.,	29 859	29·926	29·911
" " for the Month,	29·850	29·921	29 911
Force of Vapor—Greatest—Inches,	·695 in	·731 in.	·731 in.
" " " date,	6th	7th	7th, 1861
" " Least—Inches,	·133	·122	·065
" " " date,	27th	28th	21st, 1859
" " Means at 7 A. M.,	·340	·373	·320
" " " 2 P. M.,	.378	·415	·352
" " " 9 P. M.,	·365	·410	·328
" " " for the month,	·361	·399	·333
Relative Humidity—Greatest per cent.,	97· per ct.	97· per ct.	97· per ct.
" " " date,	2d	19th	Often.
" " Least per cent,	33·	33.	23·
" " " date,	22d	28th	21st, 1859
" " Means at 7 A. M.,	79 5	81·4	78·6
" " " 2 P. M.,	59·7	59·7	57·0
" " " 9 P. M.,	73·5	76·5	73·7
" " " for the month,	70·9	72·5	69·8
Clouds—Number of Clear days,*	12	10	9·5
" " Cloudy days,	19	21	21 5
" Means of sky cov'd at 7 A. M.,	53·9 per ct.	69·7 per ct.	56·5 per ct.
" " " " 2 P. M.,	51·9	61·0	54 6
" " " " 9 P. M.,	49·3	48·1	40 4
" " " for the month,	51·7	59·6	50·5
Rain—Amount in inches,	4·160 in.	3·597 in.	2·964 in.
Number of days on which Rain fell,	11·	10·	9·
Prevailing Winds,	N 73° 30′ w. ·163	N 75° 10′ w ·211	N. 73° 39′ w ·242

* Less than one-third covered at the hours of observation.

INDEX.

PAGE.

Adamas as a substitute for Metals in Gas Burners, &c. . . 187
Agitating and Mixing Substances,—Notice of G. L. Witsill's Machine for 358
Air in Conduit Pipes,—Theoretical Formulæ for the movement of . 1
Amalgamating Zinc,—A new method of . . . 179
American Court of the International Exhibition in London, . . 170
Angle Iron and Keel Gutter,—Notice of J. W. Nystrom's specimens of . 68
Angles in Parallel Open Work Girders,—Economic . 21, 81
Arches and Suspension Chains,—The Strain on . . 210, 300
Armor-Plated Ships,—On the employment of Galvanized Iron for . 59
——— Plates,—On the Manufacture of . . . 38
Artificial Stone,—Process for making an . . . 156
Asphaltum for the preservation of Boilers and Heaters,—Oil of . 399
Atrato River,—J. C. Trautwine's Remarks concerning Surveys of the . 27
Australian and other Coals,—Report on . . . 210

Baker's last Batch from Pompeii, An ancient . . 409
Bank-note Splitting,—A notice of . . . . ib.
Barlow (Professor) Notice of the Death of . . 134
Beams,—Problem on Open-built 385
Benzine Detector,—Notice of Smith & Jones's Naphthometer, or . 68
Bibliographical Notice.
Report on the Physics and Hydraulics of the Mississippi River, . 139
Boilers and Hooping of Flues,—Safe Working Pressure of . 132
———,—Apparatus for Avoiding Scales in . . . 48
Boiler Explosion near Wigan,—Account of a fatal . . 418
Borings,—On some recently executed Deep Wells and . . 223, 305
Boyden (U. A.) on Explosions produced by Nitre in Burning Buildings, . 32
Brick-work,—On the Salting of 60
Bridge across the River Tamar,—Description of the . . 73
——— Tubes,—The Stresses on the Conway . . 313
Bronze for Statues, &c.,—Description of a Golden . . 131
Bronzes Manufactured by Warner, Miskey, & Merrill,—Notice of . 215
Bryson (W.) on the Strength of Cast Iron and Timber Pillars, . 42, 121, 337
Burlington Tunnel. By S. Huntington, Jr.,—Description of the . 374
Burnt Wood-work,—Ornamental 131

Cable,—Ratan Deep Sea Electric Telegraph . . . 51
Camera Obscura,—Notice of G. T. Kolb's . . . 358
Carbolic Acid for Engineers,—On the Uses of . . 275
Carbonic Oxides,—The Poisonous Effects of . . . 49
Carding Engine,—Re-issue of Patent to J. Dyson for . . 198
Castings,—Notices of Gigantic Iron . . 58, 193
Cast Iron and Timber Pillars,—Bryson on the Strength of 42, 121, 337
——— in Sea Water,—On the Durability of . . . 327
———,—Remarks on 106
Caustic Solution Bottles,—Stoppers for . . . 214
Chemistry of Digestion,—Dr. Marcet's Lecture on the . . 404
Coal for Fuel,—Process for Compressing . . . 57
——— Gas,—On the Igniting Point of 90
——— Oil Lamps,—Notice of G. G. Custer's Improved . . 359
———,——— Mr. Mowry's . . . ib.
———,——— W. Jones's Heater for . . 68
——— Pyrometer, Notice of G. Tagliabue's, . . . 425
———,—W. W. Smyth's Lecture on . . . 404
Coals,—Report on Australian and other . . . 210
Collieries,—Giffard's Injector applied for the Drainage of . . 101

Color Signals,—Notice of A. F. Ward's Semiphoric . . 68
Condensers,—W Sewell on Surface . . . 348
Conduit Pipes,—Theoretical Formulæ for the Movement of Air in . 1
Cotton,—Dr. G. Emerson's Remarks on the cultivation of . 423

Delta of the Danube and of the works recently executed at the Salina Mouth,—Description of the 161
Dialysis,—Lecture on Mr. Graham's Researches in . 181, 253
Digestion,—Dr. Marcet's Lecture on the Chemistry of . . 404
Drainage of Collieries,—Giffard's Injector applied for the . . 101
Dyeing,—The action of Mordants in . . . 400

Earth,—On the Rigidity of the 408
Electric Light Regulator,—Description of M. Serrin's . . 415
———— Telegraph Cable,—Ratan Deep Sea . . . 51
Electrical Tests employed during the Construction of the Malta and Alexandria Telegraph, and on Insulating and Protecting Submarine Cables, . 166
Electricity,—Description of the mode and apparatus for transmitting Despatches and small articles by the agency of . . . 404
Electrolysis,—Preliminary on the production of Vibrations and Musical Sounds by 121
Engineering,—M'Elroy's Papers on Hydraulic . 13, 145, 216, 289, 361
Engineers,—On the Uses of Carbolic Acid for . . 275
Exhibition,—The American Court of the London International, . . 170
Explosion near Wigan,—Account of a fatal Boiler . . 418
———— of a Steam Boiler at I. P. Morris & Co.'s Works,—Report on 137
Explosions,—On some of the Causes, Effects, and Military Applications of . 124
————,—Proceedings of the Association for the Prevention of Steam Boiler 177, 271
———— produced by Nitre in Burning Buildings,—U. A. Boyden on . 33

Fermentation,—Influence of Silica on . . . 41
Fire Arms Manufactured by A. Jenks & Son,—Notice of . . 215
Flues,—Safe Working Pressure of Boilers and Hooping of . 132
Force, Motion, and Inertia,—Remarks on . . 109, 194
——, Prof. Tyndale's Lecture on . . . 266, 331
Foucault Telescope,—An Account of the Great . . . 335
Fruit Trees from Frost,—Method of Preserving . . 53
Fuel,—Process for Compressing Coal for . . . 57
Furnace as applied to Glass-houses, Puddling, &c.,—On a Regenerative Gas 243

Franklin Institute.
Proceedings of Stated Monthly Meetings, . 67, 135, 214, 281, 355, 421

Committee on Science and the Arts.
Report on an Explosion of a Steam Boiler at I. P. Morris & Co.'s Works, 137

Gas Burners, &c.,—On the use of Adamas as a substitute for Metal in . 187
——Engine,—Description of a New 176
——Furnace as applied to Glass-houses, Puddling, Heating, &c.,—On a Regenerative 243
——,—On the Igniting Point of Coal 90
—— Works,—On the Waste Products of 94
Giffard's Injector applied for the Drainage of Collieries, . . 101
————, J. W. Nystrom on 391
Girders,—Economic Angles in Parallel Open-work . . . 21, 81
———,———— Construction of . 82, 150, 229, 312, 374
———,—On Single and Continuous Straight . . 88
Glass,—Process of Silvering 41
Governor for Steam Engines,—Notice of Evans & Jenkins' Spring . 359
Grain Binders,—Notice of Mr. Burson's . . . 283
Gries (Major John M)—Resolutions relating to the Death of . 136
Gum Elastic Handles for Swords and Tools,—Notice of C. Bogia's . 68
Gun Metal,—Composition of a New . . . 38
——powder,—A New Manufacture of . . . 326

Hands,—Means of removing Nitric Acid Stains from the . 181
Hat Bodies,—Extension of a Patent to H. A. Wells for Hardening . 61
—— Gauge or Pyrometer,—Notice of E. Brown's . . 137
Heaters,—Oil of Asphaltum for the preservation of Boilers and . . 399
Hibiscus Moscheutos, or American Jute,—Remarks by H. Howson on the 355
Huntington, Jr. (S.) Description of the Burlington Tunnel, . 374
Hydraulic Engineering,—M'Elroy's Papers on, . 13, 145, 217, 289, 361
———— Presses,—Remarks on . . . 325

India Rubber Varnish,—Process for making . . . 108
Inertia,—Remarks on Force, Motion, and . . . 109, 194
Instantaneous Light,—History of the Manufacture of . . 410
Iron and its Resistance to Projectiles at High Velocities,—The Properties of 261, 319
——— Keel Gutters,—Notice of J. W. Nystrom's Specimens of Angle 68
——— Steel,—Process for Hardening . . . 266
——— Timber Pillars,—Bryson on the Strength of Cast 42, 121, 337
—— as regards the power of receiving and retaining Induced Magnetism of Subpermanent character,—On the difference in the properties of Hot and Cold Rolled Malleable 353
—— Castings,—Notices of Gigantic . . . 58, 193
—— for Armor-plated Ships,—On the employment of Galvanized . 59
—— from Great Britain,—Statistics of the Exportation of . 403
——,—Gigantic Masses of Rolled and Forged, . . . ib.
—— in Construction,—On the Strength of . . 192
——,—On the presence of Titanium in . . 400
—— Puddling,—Desulphuration of . . . 53
—— in Sea Water,—On the Durability of Cast . . 327
——,—On the Tensile Strength of 346
——,—Remarks on Cast 106

Jute,—H. Howson's Remarks on the Hibiscus Moscheutos, or American . 355

Lamp,—Notice of G. G. Custer's Improved Coal Oil . . 359
———————— Mr. Mowry's ———————— . . ib.
———————— W. Jones's Heater for ———— . . 68
Land from the Sea and Estuaries,—On Reclaiming . . 157
Lead,—Mode of Purifying Water from . . . 212
Light,—History of the Manufacture of Instantaneous . . 410
———Regulator,—Description of M. Serrin's Electric . . 415
Lucifer Matches,—Recent Improvements in . . . 212

McElroy (S.) Papers on Hydraulic Engineering, . 13, 145, 217, 289, 361
Malleable Iron, as regards the power of receiving and retaining Induced Magnetism of Subpermanent character,—On the difference in the properties of Hot and Cold Rolled 353
Matches,—History of the Manufacture of . . . 410
————,—Recent Improvements in Lucifer . . . 212
Metal for Gas Burners, &c.,—On the use of Adamas as a substitute for 187
Meteorology of Philadelphia, . 70, 143, 216, 287, 360, 426
Mica and its uses, ... 129
Military Applications of Explosions,—On some of the Causes, Effects, and 124
——— Cap,—Notice of W. F. Warburton's new . . 215
Mississippi River,—Notice on the Report on the Physics and Hydraulics of the 139
Mixing Substances,—Notice of G. L. Witsill's Machine for Agitating and . 358
Momentum and Vis Viva,—Prof. Wood on . . 351
Mordants in Dyeing,—The action of . . . 400
Motion and Inertia,—Remarks on Force, . . 109, 194
Mount Cenis,—Description of the Tunnel through . . 377
Musical Sounds by Electrolysis,—Preliminary Note on the production of Vibrations and 121

Nails,—Notice of Spiral-fluted . . . 105
Naphthometer or Benzine Detector,—Notice of Smith & Jones's . . 68
Nitrate of Soda in the neighborhood of the River San Francisco, . 213
Nitre in Burning Buildings,—U A. Boyden on Explosions produced by . 32
Nitric Acid Stains from the Hands,—Means of removing . . 180
Nystrom (J. W.) on the Stability of Vessels in water, . . . 53
——— ——— on Giffard's Injector, . . . 391

Oil Cups for Machinery,—Notice of W. W. W. Wood's Improved . 359
— Lamps,—Notice of G. G. Custer's Improved Coal . . ib.
——— ——— Mr. Mowry's——— . . ib.
——— ——— W. Jones's Heater for . . 68
— of Asphaltum for the preservation of Boilers and Heaters, . . 399
— Pyrometer,—Notice of G. Tagliabue's Coal . . 425
Oils,—On Paraffin, ... 399
Omnibus,—Description of Improvement of Seats for an . . 135
Ordnance,—Remarks on the Difficulties in the Fabrication of Heavy . 284

Paddle-wheel without Floats,—Notice of a . . . 105
Paper,—A Notice of splitting Bank-notes and . . . 409
Paraffin Oils,—On 399
Patent Law Cases.
Decision of U. S. Patent Office in extension of Patent to H. A. Wells for hardening Hat Bodies, . . . 61
Re-issue to J. Dyson for Carding Engine, . . 198
Interference Case,—Improvement in Stoves, . . 277
Photograph Albums bound in Family Bibles, Notice of C. H. Yost's 425
Photographs by Steam,—The production of . . 208
Pillars,—W. Bryson on the Strength of Cast Iron and Timber . 42, 121, 337
Pipes,—Theoretical Formulæ for the movement of Air in Conduit . 1
Platinum,—Method of Cleaning 180
Poisonous Effects of Carbonic Oxides, . . . 49
Pompeii,—A Baker's last Batch from . . . 409
Porte-Monnaies for Postage Stamps,—Notice of T. Hamilton's . 425
Presses,—Remarks on Hydraulic . . . 325
Projectiles at high velocities,—The properties of Iron and its resistance to 261, 319
——— ———,—Notice of Cooley's mode of discharging . . 68
Puddling,—Desulphuration of Iron in . . . 53
Pumping Engines,—S. McElroy on . . 289, 361
Pyrometer,—Notice of G. Tagliabue's Coal Oil . . 425

Quicksilver Mines of Almaden, California,—Notice of the . 100

Railroad System,—Gerard's new 75
Railway Accidents,—Their Causes and Means of Prevention, . 19, 78
——— across the Pyrenees, ... 390
——— Statistics in Great Britain, . . . 384
Rain Storm in Philadelphia,—Account of a . . . 281
Ratan Deep Sea Electric Telegraph Cable, . . 51
Reservoir Construction,—S. McElroy on . . . 13
Rivet-making Machine,—Description of a . . . 95
Rudders for Steering Ships under Steam, . . . 251

Safety Valves for Steam Boilers,—Remarks on . . 326
Salting of Brick-work,—On the 60
Scales in Steam Boilers,—Apparatus for avoiding . . 48
——— for Iron Manufacturers,—Notice of A. B. Davis's Weighing . 359
Sea Water at different depths and in different latitudes,—On the constitution of 401
——— ———,—On the Durability of Cast Iron in . . 327
Seat,—On the best Form and Dimensions of a . . . 274
Seats for an Omnibus,—Description of improved . . 135

Sewell (W.) on Surface Condensers, ... 349
Sextant,—Improvement on the ordinary 179
Signals,—Notice of A. F. Ward's Semiphoric Color . . . 68
Silica on Fermentation,—On the Influence of . . . 41
Silvering Glass, &c.,—Process of . . . . ib.
Soap Bubbles,—On a peculiar mode of producing . . . 99
——,—Statistics of the Consumption of 252
Soda in the neighborhood of the River San Francisco,—Nitrate of . 213
Stains from the Hands,—Means of removing Nitric Acid . . 180
Statues,—Description of a Golden Bronze for . . . 131
Steam Boiler Explosion,—Account of a fatal 418
———————— at Port Richmond,—Report on the . 137
———————— Explosions,—Proceedings of the Association for the Prevention of 177, 271
——— Boilers and Heaters,—Oil of Asphaltum for the preservation of . 399
——— Boilers and Hooping of Flues,—Safe Working Pressure of . 132
————————,—Remarks on Safety Valves for . . 326
———,—Description of a Rudder for Steering Ships under . . 251
——— Engines,—Notice of Evans & Jenkins's Spring Governor for . 359
———,—On the laws of Expansion of superheated . . 173
———,—The production of Photographs by . . . 208
———, W. Rowell's Remarks on Superheated . . . 422
Steamer New Ironsides,—Notice of the United States . . 284
Steel,—A new method of Melting large masses of . . 334
——,—Process for Hardening Iron and . . . 266
Steering Ships under Steam,—Description of a Rudder for . 251
Stone,—Process for making an Artificial . . . 156
Stoves,—Patent Law Case—Abbott & Lawrence vs. J. Spear—Interference, 277
Stoppers for Caustic Solution Bottles, . . . 214
Submarine Cable,—On Insulating and Protecting . . 166
Surface Condensers,—W. Sewell on . . . 348
Suspension Chains,—The Strain on Arches and . . 240, 300

Telegraph,—On the Electric Tests employed during the construction of the Malta and Alexandria 166
Telegraphic Cable,—Ratan Deep Sea Electric . . . 51
Telescope,—An account of the Great Foucault . . . 335
Timber,—Method of Preserving . . . 12, 134
——— Pillars,—W. Bryson on the Strength of Cast Iron and . 42, 121, 337
———,—The Ravages of Limnoria Terebrans on Creosoted . 188
Titanium in Iron,—On the presence of . . . 400
Transmitting Despatches and small articles by the agency of Electricity,—Description of the mode and apparatus for . . 404
Trautwine (J. C.) Remarks concerning Surveys of the Atrato River, . 27
————,———— on Force, Motion, and Inertia, . 109, 194
Trees from Frost,—Method of Preserving Fruit . . . 53
Tunnel. By S. Huntington, Jr.,—Description of the Burlington . 374
———- through Mount Cenis,—Description of the . . 377

Valves for Steam Boilers,—Remarks on Safety . . 326
Varnish,—Process for making India Rubber . . . 108
Vessels in Water,—J. W. Nystrom on the Stability of . . 53
Viaduct,—Description of the Loch Ken . . . 76
Vibrations and Musical Sounds by Electrolysis,—Preliminary Note on the production of 121
Vis Viva,—Prof. Wood on Momentum and . . . 351

Water at different depths and in different latitudes,—On the constitution of Sea 401
Water from Lead,—Mode of Purifying . . . 212
———,—J. W. Nystrom on the Stability of Vessels in . . 53
———,—On the Durability of Cast Iron in Sea . . 327

Weighing Scales for Iron Manufacturers,—Notice of A. B. Davis's . 359
Wells and Borings,—On some recently executed Deep . . 223, 305
Wood (Prof. D.) on Momentum and Vis Viva, . . . 351
————————, Problem on Open-built Beams, . . . 385
——work,—Ornamental Burnt 131

Zinc,—A new method of Amalgamating . . . 179

359
3, 305
351
385
131

179